



# Amphibian diversity of a West African biodiversity hotspot: an assessment and commented checklist of the batrachofauna of the Ivorian part of the Nimba Mountains

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**Abstract.**—This article provides the first assessment and commented checklist of the anuran diversity of the Ivorian part of the Mount Nimba Integrated Nature Reserve (MNINR), West Africa. During a period of 81 days from 18 June 2018 to 17 May 2019, covering both the rainy and dry seasons, 53 amphibian species were recorded. Among these species, 30.2% were endemic to either the Upper Guinea forest zone or smaller areas within that biodiversity hotspot. The amphibian fauna of the Ivorian slope of the MNINR is very similar to those of the Guinean side of Mounts Nimba and the Guinean Simandou Range. Based on the current IUCN Red List data, several recorded species are of high conservation concern: the Critically Endangered *Nimbaphrynoides occidentalis*; the Endangered *Hyperolius nimbae*; and the Near Threatened *Leptopelis macrotis*, *Leptopelis occidentalis*, and *Odontobatrachus arndti*. Of particular interest among the survey records were the poorly known *Ptychadena arnei*, *P. pujoli*, and *P. submascareniensis*. The records of *Ptychadena retropunctata* and *Arthroleptis cruscolum* represent first country records for Ivory Coast, while the records of *Odontobatrachus arndti* and *Phrynobatrachus fraterculus* are the second records for the country. In contrast to the Guinean and Liberian parts of Mounts Nimba, the Ivorian part had never been mined or explored for mining, nor do such plans currently exist. As a result, the study area still holds intact mountain forests that include rare and unique habitats with exceptional biodiversity, which need to be preserved for future generations. Consequently, conservation strategies should minimize bush-fires in mountain grasslands, e.g., to protect the viviparous toad *N. occidentalis*. At lower elevations, it is important to encourage local activities concerning reforestation of the previously forested areas and the conservation of the (sacred) village forests.

**Keywords.** Anura, conservation, endemics, first record, Ivory Coast, UNESCO World Heritage Site, taxonomy, Upper Guinea forest

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## Introduction

Worldwide habitat loss and the consequent decline of terrestrial vertebrates have particularly severe impacts on amphibians (e.g., Lips 1999; Raxworthy and Nussbaum 2000; Hero and Morrison 2004; Stuart et al. 2004; Crawford et al. 2010). Mountainous regions are particularly important areas for the conservation of amphibians since they provide a large number of different habitat types with high species richness. In particular, the species inhabiting the higher elevations are often range restricted or endemic (Herrmann et al.

2005; Kozak and Wiens 2010; Blackburn 2008; Juárez-Ramírez et al. 2016; Portik et al. 2016; Doherty-Bone and Gvoždík 2017; Khatiwada et al. 2019; van der Hoek et al. 2019; Bittencourt-Silva et al. 2020). This pattern also applies to the West African highlands, which host unique and remarkable amphibian species (Kouamé et al. 2007; Hillers et al. 2008a; Ofori-Boateng et al. 2018). The Upper Guinean forest zone of West Africa is among the most important global biodiversity hotspots (Myers et al. 2000). Within that ecoregion, the Mounts Nimba is situated on the borders between Liberia, Guinea, and Ivory Coast, and harbors a particularly large number of

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endemic species (Schnell 1952; Angel et al. 1954a,b; Lamotte and Sanchez-Lamotte 1999; Énard and Brosset 2003; Girard 2003; Ineich 2003; Roy 2003; Monadjem et al. 2013; Decher et al. 2016; Simmons et al. 2021). Thus, this mountain range, which abruptly rises from the surrounding plains up to an elevation of 1,752 m asl, is considered of ‘Exceptionally High Priority’ for the conservation of biodiversity in the Upper Guinea forest zone (Bakarr et al. 2001).

While the amphibian fauna of Mounts Nimba ranks among the most species rich and most intensively studied of the amphibian faunas in West Africa (Rödel et al. 2004), almost all research has been done on the Guinean and Liberian parts of the mountain range (e.g., Guibé and Lamotte 1958a,b, 1963; Xavier 1978; Rödel et al. 2010; Sandberger et al. 2010; Sandberger-Loua et al. 2018a; Schäfer et al. 2019), and none has ever focused exclusively on the Ivorian part of the mountains. One particular research focus was on the viviparous toad *Nimbaphrynoides occidentalis* (Angel, 1943), which is a flagship species for the conservation of the area (e.g., Lamotte 1959; Lamotte and Sanchez-Lamotte 1999; Hillers et al. 2008a; Xavier 2009; Sandberger et al. 2010; Sandberger-Loua et al. 2016, 2017, 2018b). However, although much research effort has been directed to the amphibian fauna of the Nimba Mountains, as indicated by the accumulation of tens of thousands of amphibian vouchers at the Muséum National d’Histoire Naturelle in Paris, new records and new species descriptions continue to be published from the Guinean and Liberian parts of Mounts Nimba (Rödel et al. 2009, 2010; Barej et al. 2015; Sandberger-Loua et al. 2018a). Thus, there is a pressing need to investigate the Ivorian part of the Nimba Mountains as well, and such research seems particularly urgent as the steadily increasing human population in the area is demanding access to land. As a result of armed conflicts in Ivory Coast and neighboring countries, a massive influx of refugees into the forested areas of western Ivory Coast is increasingly limiting the few remaining areas of primary rainforests (Woods 2003). The northern part of Mounts Nimba, shared between Guinea and Ivory Coast, received strict protection in 1944. The Ivorian part was gazetted as an UNESCO World Heritage Site in 1982, and declared the Mount Nimba Integrated Nature Reserve (MNINR) by the national law 2002-102 of February 2002, and the property was integrated into the public domain of Ivory Coast (Lauginie 2007). This paper presents the results of recent field surveys with the aim of providing a better understanding of the batrachofauna of the Ivorian sector of the Nimba Mountains, and this information will contribute to the long-term protection of this unique and biodiverse area.

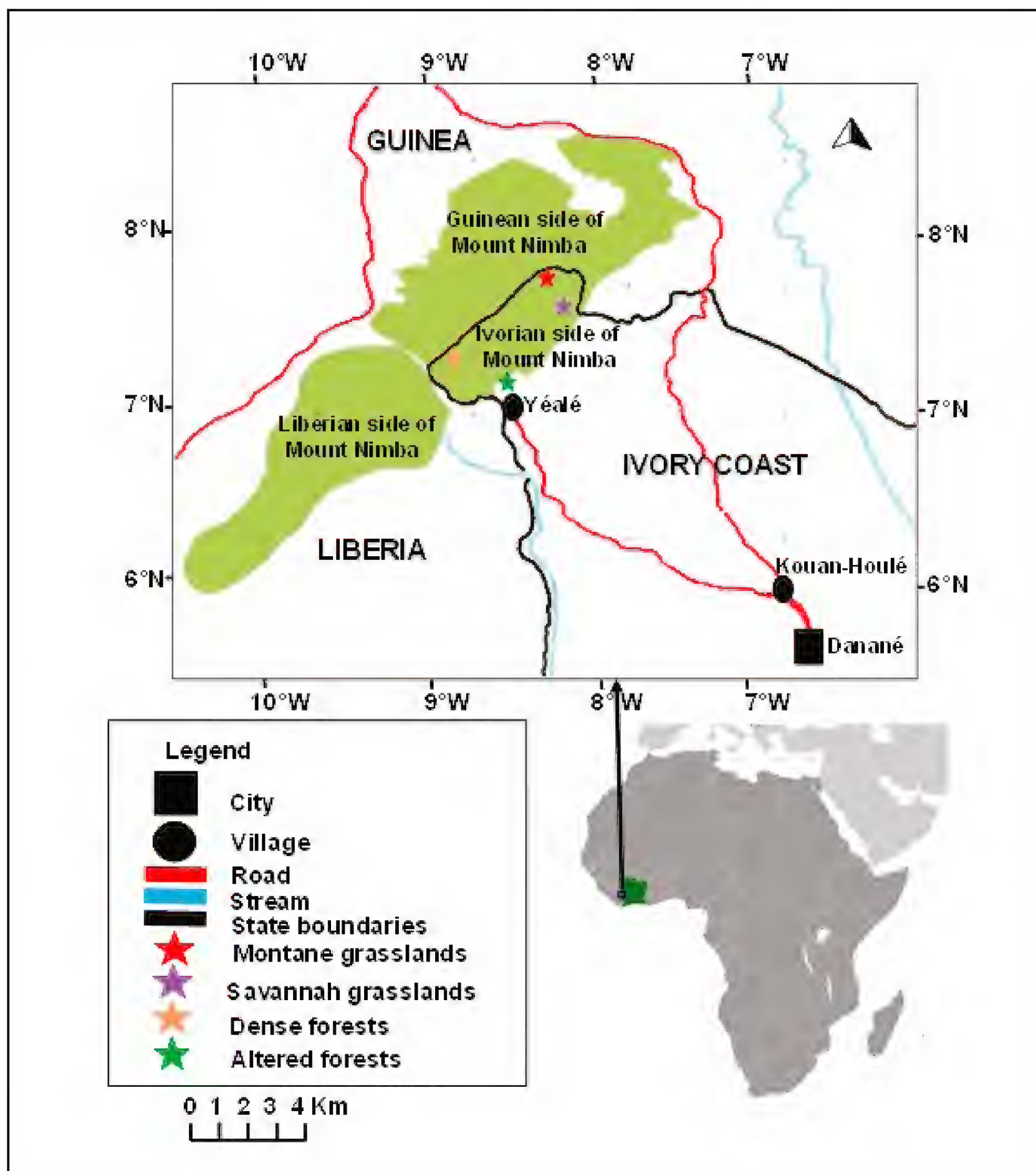
### Materials and Methods

**Study area.** Amphibian surveys were carried out in the Mount Nimba Integrated Nature Reserve (MNINR),

situated at the westernmost extension of the mountains in Ivory Coast (07°25’–07°45’N, 008°20’–008°35’W; Fig. 1). Covering 5,000 ha, the MNINR makes up only a small portion of the Nimba Mountains, while the largest part (12,540 ha) is located in Guinea. The highest peak of the Nimba Mountains is the Richard-Molard with an altitude of 1,752 m asl (Lamotte et al. 2003a,b; Lauginie 2007).

The varied geomorphology and the sub-equatorial climate, with strong seasonal and altitudinal differences, result in a variety of different microclimates. Fluctuations of mean annual temperatures range between 22–27 °C on the mountain bases to 16–21 °C on the peaks. Daily temperature fluctuations may span more than 20 °C during the dry season. Temperatures are lowest during the core rainy season from August to September, and reach highest values in March and April. The rainy season extends over eight to nine months, and is only interrupted by a short dry season from November/December to February/March. Annual precipitation varies considerably between the low and high elevations and is highest in the montane grasslands, where it may reach up to 3,500 mm. In the dry season a warm, dry and dusty wind, known as Harmattan, prevails (Lauginie 2007). Humidity in the rainy season usually exceeds 80%, but drops below 30% during Harmattan periods. The Nimba range is a water reservoir, and the source of more than 50 streams and rivers, among which the rivers Cavally, Gouè, and Nuon are of regional importance. During the rainy season, the montane parts of the mountains are mostly enveloped in clouds. The slopes are predominantly covered with dense evergreen forests at lower to mid-elevations, giving way to patches of moist savannah. Higher elevations (those above ~1,200 m asl) are dominated by montane grasslands on iron-ore ground (Lamotte 1998; Lamotte et al. 2003a,b; Lauginie 2007).

**Survey sites.** Four distinct habitat types are distinguished with different amphibian assemblages. Their definitions have been based on elevation and vegetation. Habitat A (Fig. 2) comprises montane grasslands present at the highest elevations. Habitat B (Fig. 3) is a mid-elevation savannah/grassland. An important species in the montane grasslands and mid-elevation savannah is *Loudetia kagerensis* (Poaceae), which grows on iron-oxide quartzite ground. These open habitats are frequently affected by fires during the dry season. Habitat C (Fig. 4) is dense, broadleaf and evergreen forests stretching from lower to mid-elevations (422 to 847 m asl). Torrent streams cross these mountain forests in ravines, and the water level of mountain streams decreases considerably during the dry season. Habitat D (Fig. 5) comprises altered, former forest habitat that is now inhabited predominantly by non-forest species. This area is close to Yéalé village, situated at 377 m asl, about 2 km from the periphery of the MNINR. The village area is bordered by islands of bamboo forests, partly intact forests, degraded forests with large clearings, and thick grassy



**Fig. 1.** Geographical location of the Mount Nimba Integrated Nature Reserve, within the westernmost extension of Ivory Coast at the border crossing point with Guinea and Liberia. Four distinct habitats with different amphibian assemblages based on altitudinal and vegetation types are indicated: Montane grasslands at the highest elevations (A: red star; Fig. 2); Mid-elevation savannah grasslands (B: purple star; Fig. 3); Dense, broadleaf and evergreen forests from lower to mid-elevations (C: orange star; Fig. 4); and Altered forests (D: green star; Fig. 5). The inset figure indicates the location of Ivory Coast (green patch) on the African continent.

and shrubby vegetation around houses. Cocoa and coffee plantations, small-scale subsistence farming, cultivating plantains, cassava, and corn, as well as swamps used for rice cultivation, dominate large parts of the village's surroundings.

#### **Field work, sampling effort, and vouchers.**

Despite the absence of the panzootic chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) from West Africa west of the Dahomey Gap (Penner et al. 2013; Zimkus et al. 2020), as a precaution new or disinfected equipment

was always used on each survey. Animals were mainly found opportunistically through visual encounter surveys (Heyer et al. 1994; Rödel and Ernst 2004), supplemented by acoustic surveying, lifting logs and rocks, peeling away bark, scraping through leaf litter, tufts, grasses, and broad-leaved trees, and searching around or within water-filled tree holes. Furthermore, potential breeding sites were checked for tadpoles by dip-netting. Because amphibians were not marked, repeated observations of a given individual in multiple visits cannot be excluded. Surveys of all accessible habitats were conducted by

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**Fig. 2.** Montane grasslands (habitat A) at 1,241 m asl.



**Fig. 3.** Mid-elevation savannah (habitat B).



**Fig. 4.** Lower to mid-elevation dense, evergreen forest (habitat C) at 847 m asl.



**Fig. 5.** The Yéalé village at the foothills of Mounts Nimba showing altered former forest habitat (habitat D). The mountains are visible in the background.

five people during both day (0830–1230 h GMT) and night (1800–2200 h GMT). Field work was conducted in the rainy and dry seasons, and included a total of 81 days from 18 June 2018 to 17 May 2019. Habitats B, C, and D were each investigated 56 times (day and night) during the rainy season, and 25 times (day and night) in the dry season. The montane grasslands (A) were investigated 12 times in the rainy season and seven times in the dry season, both during daytime only (Table 1). Night searches could not be conducted in this habitat, as overnight stays were not possible, and descending the mountain at night was too dangerous.

The overall sampling effort involved 3,240 person-hours. The geographical coordinates using the WGS84 datum for each site were recorded with a hand-held GPS

device (Garmin 20 etrex). The observations for each species are summarized below, and the nomenclature used herein follows Channing and Rödel (2019). Amphibians were captured by hand and identified to species level. All individuals were photographed, measured, sexed, and if not retained as vouchers, released in their respective habitats. The symbols in “\*” refer to records that probably comprises several species in the Tables and Appendix. Snout-urostyle-lengths (SUL) were taken with dial calipers (accuracy  $\pm 0.5$  mm). Voucher specimens were euthanized in a 1,1,1-trichloro-2-methyl-2-propanol hemihydrate (MS222) solution, preserved in 80% ethanol, and deposited at the Jean Lorougnon Guédé University, Daloa, Ivory Coast. The numbers of retained vouchers (NGK) are listed with the species accounts.

**Table 1.** Number of daily searches, during the 81 day period from 18 June 2018 to 17 May 2019, in each of the four habitat types (A, B, C, and D) in Mount Nimba Integrated Nature Reserve. The habitat types are described in the “Survey Sites” section in **Materials and Methods**.

Habitat A				Habitat B				Habitat C				Habitat D			
Dry season		Rainy season		Dry season		Rainy season		Dry season		Rainy season		Dry season		Rainy season	
Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
5	0	12	0	25	25	56	56	25	25	56	56	25	25	56	56

**Statistics.** As most data were collected opportunistically (and are thus not strictly quantitative), only the Chao2 and Jackknife1 estimators, both based on presence/absence data and for all habitats, were used to calculate expected species richness and thus sampling efficiency, using the software EstimateS (Colwell 2006). Calculations were based on the daily species lists (81 days of survey work) for all 53 amphibian taxa recorded in MNINR. To avoid order effects, calculations were based on 500 randomized runs of the daily species lists. The Sørensen's similarity index ( $\Pi$ ), which varies from 0 to 1 (Sørensen 1948; Wolda 1981), was used to determine species similarity between the four habitat types (A, B, C, and D). Likewise,  $\Pi$  was used for pairwise comparisons between species overlap with the MNINR (this study) and eight nearby and surrounding sites in the western part of the Upper Guinean hotspot that were previously surveyed (Chabanaud 1920, 1921; Parker 1936; Guibé and Lamotte 1958a, 1963; Laurent 1958; Schiøtz 1967; Taylor 1968; Böhme 1994a,b; Lamotte and Ohler 1997, 2000; Rödel 2003; Rödel and Ernst 2003; Rödel and Bangoura 2004; Rödel et al. 2004; Ernst et al. 2006; Hillers et al. 2008a; Barej et al. 2015; Sandberger-Loua et al. 2018; Schäfer et al. 2019). The *Hyperolius* sp. by Hillers et al. (2008a) from Fouta Djallon was *H. occidentalis* (N.G. Kouamé, pers. obs.). Because the intraspecific morphological variation of frogs from the West African *Arthroleptis poecilonotus*-complex (< 30 mm snout-urostyle length) overlaps with interspecific variation, it is currently not possible to distinguish these frogs at the species level based on morphological characteristics alone (Rödel and Bangoura 2004). Advertisement calls of our records hint that these squeaker frogs may actually represent several taxa, but are treated herein as one taxon, termed *Arthroleptis poecilonotus*-complex. Apart from *Hyperolius* sp., the records of frogs not identified to the species level were excluded from the calculations of the Sørensen index.

## Results

### Species Richness and Faunal Similarities

A total of 53 anuran species were recorded in MNINR. A list of all taxa with site records, known general habitat preferences, distribution range, and the current IUCN Red List category is provided in Table 2. Concerning range, our definition of West Africa follows Penner et al. (2011), i.e., a region extending from Senegal in the west to the Nigerian Cross River in the east. Using the estimators, we calculated 53 (sd:  $\pm 0.62$ ; Chao 2) and 54 (sd:  $\pm 1.39$ ; Jack-knife 1) anuran species to occur in the study area. Thus, we found almost the entirety of the species richness (100% and 96.29%, respectively) for the Ivorian sector of Mounts Nimba.

Approximately one-third (16 spp., 30.2%) of the recorded species are restricted to the Upper Guinean

forest zone, while another one-third (16 spp., 30.2%) are even further limited to the western part of this biodiversity hotspot. Two species (3.8%), *Hyperolius nimbae* and *Nimbaphrynoides occidentalis*, are endemic to the Nimba area; while eight species (15.1%) have a larger West African range. Eleven species (20.75%) are known to occur beyond West Africa (Table 2).

Over one-quarter of the species encountered (14 sp., 26.4%) require forest habitats. Among them, eight species (15.1%) are typical savannah specialists; five (9.4%) occur in farmbush (degraded forest) habitats, while 11 (20.8%) are known to inhabit savannah and farmbush habitats; nine (17%) are known from forest and savannah habitats; and two species (3.8%), *Phrynobatrachus gutturosus* and *Ptychadena arnei*, have been recorded across the entire broad habitat range from savannah and farmbush to forest (Table 2).

Concerning the habitat specific species richness in MNINR, the following species numbers were recorded in each of the four distinct habitats: four species in A, eight in B, 21 in C, and 32 in D. Two species (*Phrynobatrachus tokba* and *Ptychadena submascareniensis*) were common to habitats A and B, while three (*Astylosternus occidentalis*, *Sclerophrys maculata*, and *Phrynobatrachus tokba*) were common to B and C. Three species (*Leptopelis viridis*, *Sclerophrys maculata*, and *Hoplobatrachus occipitalis*) occurred in B and D, and five (*Arthroleptis poecilonotus*-complex, *Leptopelis macrotis*, *Sclerophrys maculata*, *Hyperolius chlorosteus*, and *Kassina cochranæ*) were found in C and D (Table 2). Habitat A showed the highest species overlap/similarity ( $\Pi$ -value: 0.33) with habitat B; habitat B shared a mean species overlap/similarity ( $\Pi$ -value: 0.21) with habitat C, and the lowest species overlap/similarity ( $\Pi$ -value: 0.21) with habitat D ( $\Pi$ -value: 0.15); while habitat C shared a low species overlap/similarity ( $\Pi$ -value: 0.19) with habitat D.

One species, *Phrynobatrachus tokba*, occurs in forest, farmbush habitats, and montane grasslands; another species (*Ptychadena submascareniensis*) inhabits savannah and montane grasslands; while two species (3.8%), *Arthroleptis cruscolum* and *Nimbaphrynoides occidentalis*, are confined to montane grasslands only (Table 2).

With respect to the IUCN status of threatened species, one species (*Nimbaphrynoides occidentalis*) is ranked as Critically Endangered; one species, *Hyperolius nimbae*, is listed as Endangered; four (*Arthroleptis cruscolum*, *Leptopelis macrotis*, *L. occidentalis*, and *Odontobatrachus arndti*) are Near Threatened; and four (*Hyperolius soror*, *Ptychadena arnei*, *P. pujoli*, and *P. submascareniensis*) are Data Deficient.

The results of the Sørensen's similarity index for pairwise comparisons between the MNINR (this study) and eight nearby and surrounding sites from the western part of the Upper Guinean hotspot are presented in

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**Table 2.** Amphibian species recorded in the Mount Nimba Integrated Reserve with respective habitat records, known habitat preferences, distribution range, and IUCN Red List category. Habitats A, B, C, and D are described in the “Survey Sites” section in Materials and Methods. AF = Africa (any range beyond West Africa), WA = West Africa (defined as the area west of the Cross River in Nigeria), UG = Upper Guinea (defined as forest zone west of the Dahomey Gap), wUG = western Upper Guinea (defined as any range from western Ivory Coast or beyond the western part of this country), E = endemic to Mounts Nimba; S = savannah, MG = montane grasslands, FB = farmbush (degraded and secondary forest), F = forest; IUCN categories: LC = Least Concern, NT = Near Threatened, EN = Endangered, CR = Critically Endangered, NE = Not Evaluated by IUCN.

Families and species	Habitats				Distribution range					Habitat preferences				IUCN Red List
	A	B	C	D	AF	WA	UG	wUG	E	S	MG	FB	F	
<b>Arthroleptidae</b>														
<i>Arthroleptis crusculum</i>	X							X			X			NT
<i>Arthroleptis poecilnotus-complex*</i>			X	X			X					X	X	NE
<i>Astylosternus occidentalis</i>		X	X					X					X	LC
<i>Cardioglossa occidentalis</i>			X				X						X	NE
<i>Leptopelis macrotis</i>			X	X			X						X	NT
<i>Leptopelis occidentalis</i>			X				X						X	NT
<i>Leptopelis spiritusnoctis</i>			X				X					X	X	LC
<i>Leptopelis viridis</i>		X		X	X					X		X		LC
<b>Bufonidae</b>														
<i>Nimbaphrynoides occidentalis</i>	X								X		X			CR
<i>Sclerophrys maculata</i>		X	X	X	X					X		X		LC
<i>Sclerophrys regularis</i>				X	X					X		X		LC
<i>Sclerophrys togoensis</i>			X				X						X	LC
<b>Conrauidae</b>														
<i>Conraua alleni</i>			X					X					X	LC
<b>Dicroglossidae</b>														
<i>Hoplobatrachus occipitalis</i>		X		X	X					X		X		LC
<b>Hemisotidae</b>														
<i>Hemisis marmoratus</i>				X	X					X				LC
<b>Hyperoliidae</b>														
<i>Afrixalus dorsalis</i>				X		X				X		X		LC
<i>Afrixalus fulvovittatus</i>				X			X					X		LC
<i>Hyperolius chlorosteus</i>			X	X				X					X	LC
<i>Hyperolius concolor</i>				X			X			X		X		LC
<i>Hyperolius fusciventris fusciventris</i>				X				X				X		LC
<i>Hyperolius guttulatus</i>				X		X						X	X	LC
<i>Hyperolius lamottei</i>		X						X		X				LC
<i>Hyperolius nimbae</i>				X					X			X		EN
<i>Hyperolius picturatus*</i>				X			X					X	X	LC
<i>Hyperolius soror</i>			X					X				X		DD
<i>Hyperolius cf. sylvaticus</i>				X			X					X	X	LC
<i>Hyperolius sp.</i>				X				X				X		NE
<i>Kassina cochranae</i>			X	X				X		X		X		LC
<b>Odontobatrachidae</b>														
<i>Odontobatrachus arndti</i>			X					X					X	NT
<b>Phrynobatrachidae</b>														

**Table 2 (continued).** Amphibian species recorded in the Mount Nimba Integrated Reserve with respective habitat records, known habitat preferences, distribution range, and IUCN Red List category. Habitats A, B, C, and D are described in the “Survey Sites” section in Materials and Methods. AF = Africa (any range beyond West Africa), WA = West Africa (defined as the area west of the Cross River in Nigeria), UG = Upper Guinea (defined as forest zone west of the Dahomey Gap), wUG = western Upper Guinea (defined as any range from western Ivory Coast or beyond the western part of this country), E = endemic to Mounts Nimba; S = savannah, MG = montane grasslands, FB = farmbush (degraded and secondary forest), F = forest; IUCN categories: LC = Least Concern, NT = Near Threatened, EN = Endangered, CR = Critically Endangered, NE = Not Evaluated by IUCN.

Families and species	Habitats				Distribution range					Habitat preferences				IUCN Red List
	A	B	C	D	AF	WA	UG	wUG	E	S	MG	FB	F	
<i>Phrynobatrachus alleni</i>			X				X						X	LC
<i>Phrynobatrachus annulatus</i>			X				X						X	LC
<i>Phrynobatrachus francisci</i>				X		X				X				LC
<i>Phrynobatrachus fraterculus</i>			X					X				X	X	LC
<i>Phrynobatrachus guineensis</i>			X					X					X	LC
<i>Phrynobatrachus gutturosus*</i>				X		X				X		X	X	LC
<i>Phrynobatrachus latifrons</i>				X		X				X		X		LC
<i>Phrynobatrachus liberiensis</i>			X				X						X	LC
<i>Phrynobatrachus natalensis</i>				X	X					X				LC
<i>Phrynobatrachus phyllophilus</i>			X				X						X	LC
<i>Phrynobatrachus tokba</i>	X	X	X				X				X	X	X	LC
<b>Pipidae</b>														
<i>Xenopus tropicalis</i>				X		X						X	X	LC
<b>Ptychadenidae</b>														
<i>Ptychadena arnei</i>				X				X		X		X	X	DD
<i>Ptychadena bibroni</i>				X	X					X		X		LC
<i>Ptychadena longirostris</i>			X			X						X	X	LC
<i>Ptychadena oxyrhynchus</i>				X	X					X		X		LC
<i>Ptychadena pujoli</i>				X				X		X				DD
<i>Ptychadena pumilio</i>				X	X					X		X		LC
<i>Ptychadena retropunctata</i>		X						X		X				LC
<i>Ptychadena stenocephala</i>				X	X					X				LC
<i>Ptychadena submascareniensis</i>	X	X						X		X	X			DD
<i>Ptychadena tournieri</i>				X		X				X				LC
<b>Ranidae</b>														
<i>Amnirana</i> sp. ‘albolabris west’				X			X					X	X	NE
<b>Rhacophoridae</b>														
<i>Chiromantis rufescens</i>				X	X								X	LC

Table 3. Among the Ivorian sites, the Taï National Park had the highest similarity ( $\Omega$ -value: 0.62) with MNINR concerning amphibian assemblage composition. More than half of the anuran fauna of MNINR was also shared with the Mount Sangbé National Park ( $\Omega$ -value: 0.58) and the Mount Péko National Park ( $\Omega$ -value: 0.54), two mountainous areas in western Ivory Coast. Naturally,

our survey area was most similar to the amphibian fauna of the Guinean part of Mounts Nimba (79% similarity). With 72% and 67% similarity, the Guinean Simandou range and Diécké Classified Forest likewise had faunas that were very similar to the MNINR. In contrast the Fouta Djallon, the westernmost part of the Upper Guinea highlands, comprising savannah, limited forest, and

## Amphibians of the Nimba Mountains (Ivorian part)

**Table 3.** Sørensen's Similarity Value ( $\eta$ ) between the anuran fauna of the Mount Nimba Integrated Reserve and nearby and surrounding sites from the western part of the Upper Guinean hotspot of West Africa, including respective species richness. Area abbreviations: DCF = Diécké Classified Forest; FD = Fouta Djallon Highlands; MB = Mount Béro; MN = Mount Nimba; MP = Mount Péko National Park; MS = Mount Sangbé National Park; SR = Simandou range; ZCF = Ziama Classified Forest. Literature records were adjusted to reflect recent taxonomic changes.

Area	Species richness	Number of species common with this study	$\eta$ -value (Sørensen)	Source
MP (Ivory Coast)	29	22	0.54	Rödel and Ernst (2003)
MS (Ivory Coast)	44	28	0.58	Rödel (2003); Barej et al. (2015)
TNP (Ivory Coast)	53	33	0.62	Rödel and Ernst (2003); Ernst et al. (2006)
DCF (Guinea)	39	31	0.67	Rödel et al. (2004)
FD (Guinea)	26	15	0.38	Hillers et al. (2008a); Barej et al. (2015)
MB (Guinea)	28	22	0.54	Rödel et al. (2004)
MN (Guinea)	56	43	0.79	Guibé and Lamotte (1958a, 1963); Laurent (1958); Schiøtz (1967); Lamotte and Ohler (1997, 2000); Rödel et al. (2004); Barej et al. (2015); Sandberger-Loua et al. (2018); Schäfer et al. (2019)
SR (Guinea)	52	38	0.72	Parker (1936); Taylor (1968); Rödel and Bangoura (2004)
ZCF (Guinea)	31	20	0.48	Chabanaud (1920, 1921); Böhme (1994a,b)

rivers with waterfalls, only shares 38% of the species with MNINR (Table 3).

### Species Accounts

After each species name the numbers of retained vouchers (NGK-Nimba) are listed.

#### Arthroleptidae

##### *Arthroleptis cruscum* Angel, 1950

Evening Squeaker

**Material:** Two males, NGK-Nimba 0019, NGK-Nimba 0130 (Fig. 6A). **Comments:** On a rainy day they were found together with a juvenile Nimba Toad (*N. occidentalis*) below a stone in montane grassland (07°35.555'N, 008°25.788'W; 1,235 m asl). These males had an oval to slender elongated body and measured 15.5 and 21.0 mm SUL, respectively. *Arthroleptis cruscum* always possesses a granular to warty dorsal skin. Its habitat differs from other species of the genus which are present on Mounts Nimba. *Arthroleptis nimbaensis*, *A. langeri*, and *A. krokosua*, and occur in rainforest and/or farmbush (Guibé and Lamotte 1958b; Rödel et al. 2009; Adum et al. 2011; Nopper et al. 2012; Sandberger-Loua et al. 2018a). *Arthroleptis cruscum* occurs in high elevation grasslands up to 1,750 m asl during the rainy season and seems to survive the dry season in gallery forests and at the edges of marshes (Guibé and Lamotte 1958b).

##### *Arthroleptis poecilnotus*-complex

Mottled Squeaker

**Material:** Two males, NGK-Nimba 0021 (Fig. 6B),

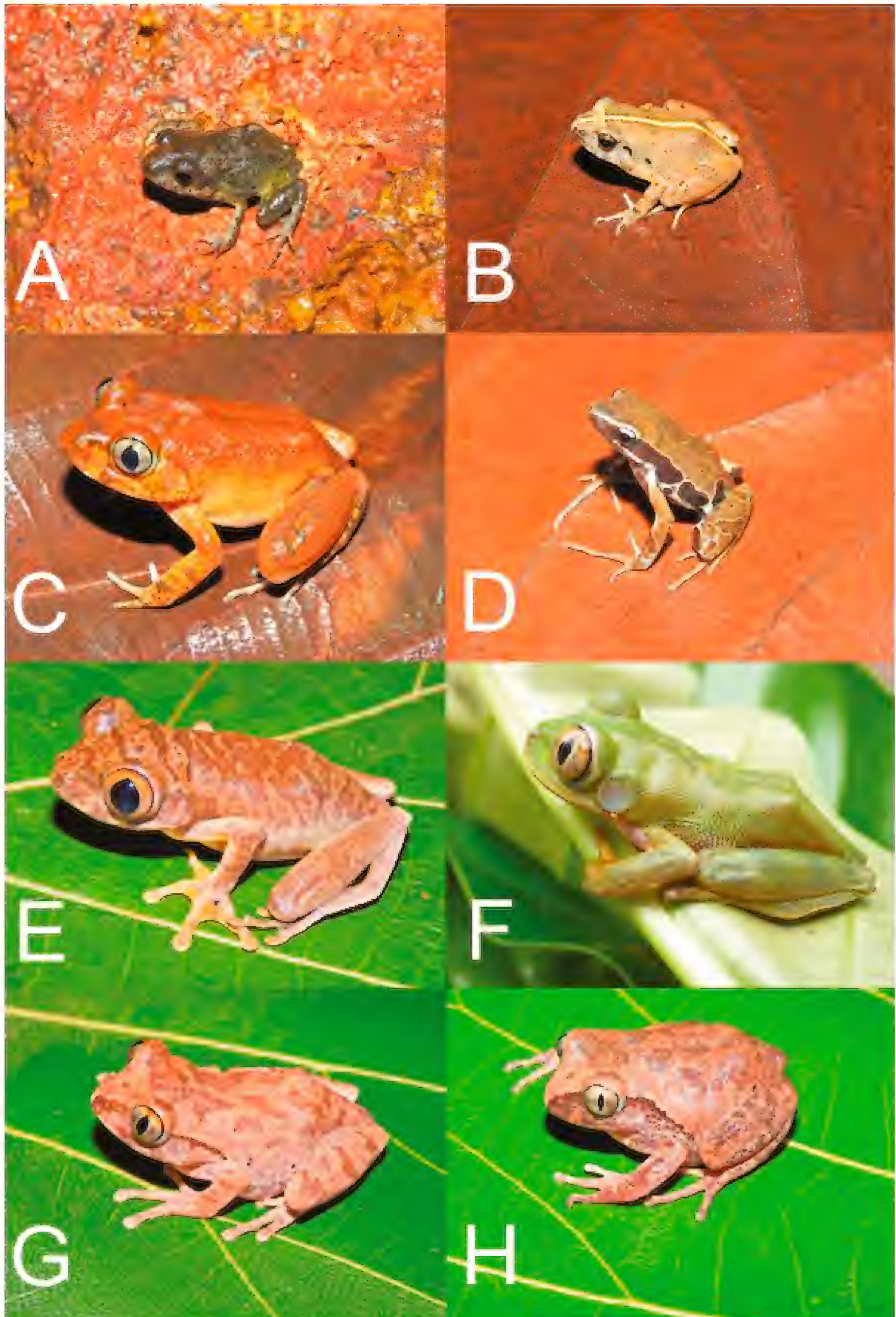
NGK-Nimba 0022. **Comments:** These squeaker frogs were widespread in the forest area as well as in farmlands within the vegetation, where several concealed males emitted their insect-like chirping calls which cannot be assigned to any morphotaxa. They occurred from 425 to 847 m asl. A male of 23.0 mm in SUL was captured in a patch of forest and retained as voucher (07°35.233'N, 008°25.190'W; 847 m asl). Another male voucher (SUL 24.0 mm) was recorded in an agricultural area (07°31.928'N, 008°25.401'W; 425 m asl). *Arthroleptis poecilnotus*-complex are larger than *A. langeri* but smaller than *A. krokosua*. The two vouchers may comprise different species, of which one could be conspecific with *A. nimbaensis*. However, currently that cannot be clarified (see Rödel and Bangoura 2004; Channing and Rödel 2019). All of these *Arthroleptis* species, apart from *A. cruscum*, may have similar habitat requirements (Rödel et al. 2009; Adum et al. 2011; Nopper et al. 2012; Sandberger-Loua et al. 2018a).

##### *Astylosternus occidentalis* Parker, 1931

Western Night Frog

**Material:** Two males, NGK-Nimba 0014, NGK-Nimba 0023, and one female, NGK-Nimba 0024 (Fig. 6C). **Comments:** While *A. occidentalis* was previously mostly recorded in patches of lowland forests (Rödel and Branch 2002; Rödel and Bangoura 2002; Ernst and Rödel 2006; Hillers and Rödel 2007; Hillers et al. 2008b; Rödel and Glos 2019), on Mounts Nimba the species occurs in altitudinal forest habitats as well (Guibé and Lamotte 1958a). During the night several active individuals were detected among leaf litter in a patch of forest (07°35.233'N, 008°25.190'W; 847 m asl), close to





**Fig. 6.** Arthroleptid frogs from Mount Nimba Integrated Nature Reserve: *Arthroleptis crusculum* male (A); *Arthroleptis poecilonotus*-complex female (B); *Astylosternus occidentalis* female (C); *Cardioglossa occidentalis* male (D); *Leptopelis macrotis* male (E); *Leptopelis occidentalis* male (F); *Leptopelis spiritusnoctis* female (G); *Leptopelis viridis* female (H).

fast-flowing streams. Male SULs ranged from 45.0–50.2 mm (N = 3), while females measured from 46.0–61.0 mm (N = 9). The majority of specimens had a dark brown dorsum, although one female exhibited an orange color. In contrast to the general forest habitat requirements of this species we found some, presumably migrating, frogs at night, in the core rainy season near a crystal-clear stream in predominantly grassy savannah (07°35.453'N, 008°24.957'W; 843 m asl). During the day, they were hidden underneath stones.

***Cardioglossa occidentalis* Blackburn, Kosuch, Schmitz, Burger, Wagner, Gonwouo, Hillers, and Rödel, 2008**

Western Long-fingered Frog

**Material:** Three males, NGK-Nimba 0025, NGK-Nimba 0026 (Fig. 6D), NGK-Nimba 0027. **Comments:** *Cardioglossa occidentalis* is a nocturnal leaf litter frog, distributed along forest streams from Sierra Leone to Ghana (Rödel et al. 2001; Rödel and Branch 2002; Ernst and Rödel 2006; Blackburn et al. 2008; Hillers et al. 2008c). During the night, males frequently emitted insect-like calls (see Rödel et al. 2001), and were well concealed below leaf litter along forest streams. Three males were collected near a small stream running through a slightly degraded forest patch that was dominated by bamboo (07°32.993'N, 008°24.753'W; 425 m asl). Their SULs ranged from 27.0–29.0 mm.

***Leptopelis macrotis* Schiøtz, 1967**

Large-eared Tree Frog

**Material:** Three males, NGK-Nimba 0017, NGK-Nimba 0018, NGK-Nimba 0131 (Fig. 6E). **Comments:** *Leptopelis macrotis* is one of the largest species in the genus. It occurs in primary forests, preferentially at the edges of streams, from eastern Sierra Leone to Ghana (Schiøtz 1967; Rödel et al. 2014; Channing and Rödel 2019). In Ivory Coast, as in its entire range, the species is threatened due to forest degradation and conversion, e.g., two of its Ivorian sites (see Rödel and Branch 2002) have been recently converted into rubber plantations (P.J. Adeba, pers. comm.). During this survey, only three males of *L. macrotis* were recorded, two of which were found during the dry season. Both frogs (45.5 and 48.5 mm SUL) were perched on a branch of a broad leaf, at ~2.5 m height, close to a large stream (07°33.121'N, 008°25.036'W; 422 m asl). The third male (42.5 mm SUL), in contrast, was found in a degraded forest during the rainy season. This male was perched on a branch, at 75 cm above the ground, close to a large stream (07°31.932'N, 008°25.508'W; 387 m asl).

***Leptopelis occidentalis* Schiøtz, 1967**

Western Tree Frog

**Material:** Male, NGK-Nimba 0016 (Fig. 6F). **Comments:** *Leptopelis occidentalis* is primarily a rainforest treefrog, preferring forests near streams, and

ranging from western Ghana, through Ivory Coast to Liberia (Schiøtz 1967; Rödel et al. 2005; Hillers and Rödel 2007; Hillers et al. 2009; Channing and Rödel 2019). After sunset (1830 h GMT), a male (41.5 mm SUL) with a uniform green dorsum was found perching on a shrub at the edge of a forest clearing along a stream (07°33.121'N, 008°25.036'W; 422 m asl). The species is known from several forests in Ivory Coast (Schiøtz 1967; Rödel and Branch 2002; Ernst and Rödel 2008).

***Leptopelis spiritusnoctis* Rödel, 2007**

Ghostly Tree Frog

**Material:** Female, NGK-Nimba 0087 (Fig. 6G).

**Comments:** *Leptopelis spiritusnoctis* inhabits patches of degraded and primary forests, from Sierra Leone to Nigeria (Schiøtz 1967; Rödel 2007; Rödel et al. 2014). During this survey we collected only one female (33.5 mm SUL) in a tree at the edge of a stream (07°33.121'N, 008°25.036'W; 422 m asl).

***Leptopelis viridis* (Günther, 1869)**

Green Tree Frog

**Material:** One male, NGK-Nimba 0083, and one female, NGK-Nimba 0086 (Fig. 6H). **Comments:** *Leptopelis viridis* is a savannah frog, which is also encountered in herbaceous vegetation from the semi-deciduous forest zone. It ranges across the northern part of sub-Saharan Africa (Schiøtz 1967; Rödel 2000; Channing and Rödel 2019). The species was recorded within grassland at the foot of Mounts Nimba (07°35.453'N, 008°24.957'W; 843 m asl). Additional populations were recorded in the Yéalé village, on shrubs, palm trees, and herbaceous plants (07°31.928'N, 008°25.401'W; 425 m asl). The males measured 32.0–34.0 mm (N = 6), while a single recorded female reached 36.0 mm SUL.

**Bufonidae**

***Nimbaphrynoides occidentalis* (Angel, 1943)**

Nimba Toad

**Material:** No voucher. **Comments:** *Nimbaphrynoides occidentalis* is a unique toad, being viviparous and endemic to a very limited range of a total of 4 km<sup>2</sup> on the ridges of the Mounts Nimba between Liberia, Guinea, and Ivory Coast (Lamotte 1959; Lamotte and Sanchez-Lamotte 1999; Hillers et al. 2008b; Sandberger-Loua et al. 2016, 2017). The toads live in montane grasslands above 1,200 m asl, where they go into dormancy during the dry season (Lamotte 1959; Hillers et al. 2008; Sandberger et al. 2010). *Nimbaphrynoides occidentalis* comprises two subspecies isolated by a forested mountain ridge: the larger *N. occidentalis liberiensis* is restricted to one site in Liberia, while *N. occidentalis occidentalis* occurs in a few sub-populations in Guinea and Ivory Coast (Sandberger et al. 2010). We found *N. occidentalis occidentalis* at 1,235 m asl, on very humid steep slopes in the montane grassland (07°35.555'N, 008°25.788'W;

1,235 m asl). Four juveniles and one female were discovered under rocks. The sizes of the juveniles ranged from 12.0–14.0 mm while the female measured 23.0 mm. The basic dorsal color of the juveniles was dark brown, with a somewhat irregular mixture of light brown and white spots. Their snout, eyelids, and legs were colored light brown. The juveniles showed a pattern typical for adult males (Fig. 7A), whereas the female had a nearly uniform light brown dorsal color (Fig. 7B). The main threat for this species in Ivory Coast is bush fires in the dry season. A detailed assessment of the distribution and population sizes of *N. occidentalis occidentalis* from Ivory Coast is urgently needed.

### ***Sclerophrys maculata* (Hallowell, 1854)**

Northern Flat-backed Toad

**Material:** Two males, NGK-Nimba 0043, NGK-Nimba 0051 (Fig. 7C), and one female, NGK-Nimba 0058 (Fig. 7D). **Comments:** *Sclerophrys maculata* is a common toad with flat and granular parotid glands living in the savannah zone and edges of heavily degraded forests (Rödel 2000; Poynton et al. 2016). Toads were found in grassy pastures at the foot of Mounts Nimba (07°35.258'N, 008°25.052'W; 821 m asl), and some females were also observed occasionally together with *S. togoensis* on forest trails (07°32.993'N, 008°24.753'W; 425 m asl). Further records were obtained in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl), mostly along dirt roads in puddles, around houses, or in plantations at swamp edges. The body sizes of two males were 46.0 and 49.0 mm, while females measured 41.5–69.0 mm (N = 5). During the reproductive period, some males exhibited a remarkable yellow color.

### ***Sclerophrys regularis* (Reuss, 1833)**

Common Toad

**Material:** Female, NGK-Nimba 0031 (Fig. 7E). **Comments:** *Sclerophrys regularis* has prominent, roundish, and smooth parotid glands. It inhabits a broad range of habitats from moist and dry savannahs to forest margins throughout tropical Africa, most often found around human settlements (Rödel 2000; Channing and Howell 2006). The species was recorded in the rainy season at Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl), where some males called in garbage pits (e.g., Fig. 7F). A female toad measured 118.0 mm, while a male's body size was 102.0 mm.

### ***Sclerophrys togoensis* (Ahl, 1924)**

Togo Toad

**Material:** Three males, NGK-Nimba 0004, NGK-Nimba 0028, NGK-Nimba 0029 (Fig. 7G), and one female, NGK-Nimba 0050 (Fig. 7H). **Comments:** This toad has a patchy distribution in primary forests from Togo to Sierra Leone, and mainly breeds in shallow forest streams during the dry season (Rödel and Bangoura 2004; Rödel et al. 2004). Four specimens were found

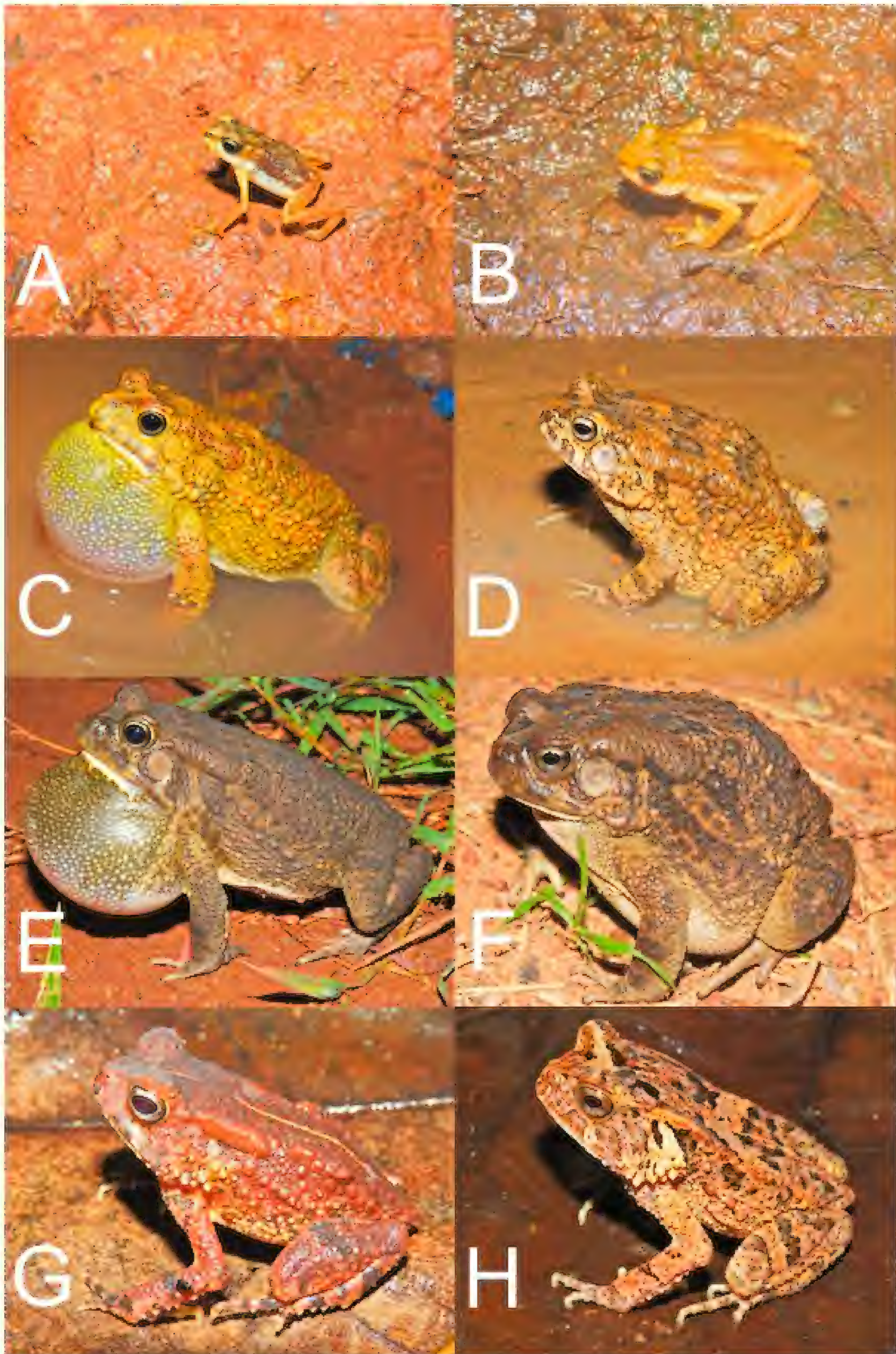
in different forest patches. The variable color pattern of this species has been described by Rödel and Bangoura (2004), Channing and Rödel (2019), and Gongomin et al. (2019). Diagnostic is the parallel, straight, narrow, and angular parotid glands, running parallel to the side of the body. Two males were encountered in a patch of dense forest crossed by a shallow stream (07°33.440'N, 008°24.657'W; 439 m asl). A female was found together with another male among humid litter on a forest trail (07°32.993'N, 008°24.753'W; 425 m asl). While the female measured 64.0 mm, the SULs of the three males ranged from 40.5–44.5 mm. In Ivory Coast, *S. togoensis* is highly threatened by deforestation (Gongomin et al. 2019).

## **Conrauidae**

### ***Conraua alleni* (Barbour and Loveridge, 1927)**

Allen's Giant Frog

**Material:** Two unsexed, NGK-Nimba 0057 (Fig. 8A), NGK-Nimba 0058, and two females, NGK-Nimba 0059 (Fig. 8B), NGK-Nimba 0073. **Comments:** *Conraua alleni* is a highly aquatic frog, which inhabits slow- to fast-flowing forest streams, from lowlands to montane forest areas. Records are known from eastern Guinea and Sierra Leone, through Liberia to western Ivory Coast, with an isolated population occurring in western Ghana (Barbour and Loveridge 1927; Guibé and Lamotte 1958a; Lamotte and Perret 1968; Rödel 2003; Rödel and Bangoura 2004; Channing and Rödel 2019; Rödel and Glos 2019; Schäfer et al. 2019). Some of these populations may comprise cryptic taxa (see Rödel and Branch 2002; Hillers et al. 2008a). We found *C. alleni* populations in streams intersecting forest patches (07°35.258'N, 008°25.052'W; 821 m asl). Other individuals were heard calling in a very impressive torrent stream in mid-elevation forest (07°34.652'N, 008°24.966'W; 716 m asl). The bird-like whistles were heard during day and night, with peaks after sunset (around 1841 h GMT). Additional populations were found at night in pools of a slow running stream with a sandy and rocky bottom. This stream crossed a slightly degraded forest patch dominated by bamboo (07°32.993'N, 008°24.753'W; 425 m asl), where a total of 14 adult frogs were caught. Through palpation of the lower abdomen, two of them were identified as gravid females. Their body size was 52.8–54.0 mm. The remaining 12 frogs ranged from 51.1–55.6 mm but could not be sexed. One adult, kept in captivity for two months, preyed on locusts, ants, spiders, caterpillars, and butterflies that were floating on the water surface. All adult *C. alleni* had a clear interorbital line, however, their back pattern varied from a darker brown with black dots and reddish legs to frogs with orange patches on the darker brown ground. In contrast to other described *C. alleni* (e.g., Channing and Rödel 2019), the venter of our frogs was golden yellow or beige to pinkish, and the thighs had a pink ventral color. The



**Fig. 7.** Bufonids from Mount Nimba Integrated Nature Reserve: *Nimbaphrynoides occidentalis* juvenile (A); *N. occidentalis* female (B); *Sclerophrys maculata* male (C), the yellow color is only exhibited by some males during breeding; *S. maculata* female (D); *S. regularis* male (E); *S. regularis* female (F); *S. togoensis* male (G); *S. togoensis* female (H).



**Fig. 8.** Conrauid, dicroglossid, hemisotid, and hyperoliids from Mount Nimba Integrated Nature Reserve: *Conraua alleni* (A–B); *Hoplobatrachus occipitalis* (C); *Hemisus marmoratus* (D); *Afrixalus dorsalis* (E); *A. fulvovittatus* (F); *Hyperolius chlorosteus* (G–H).

throat was dark, and pinkish with reddish-brown dots or uniform beige. The taxonomic status of these frogs and the populations from nearby Mount Sangbé National Park (Rödel 2003) should be investigated.

### Dicroglossidae

#### *Hoplobatrachus occipitalis* (Günther, 1858)

African Tiger Frog

**Material:** Female, NGK-Nimba 0005 (Fig. 8C).

**Comments:** *Hoplobatrachus occipitalis* is a large aquatic frog that is widely distributed in savannahs and disturbed forests across tropical Africa (Channing and Rödel 2019). A female was caught at night near a stream within pastures (07°35.453'N, 008°24.957'W; 843 m asl). Males were heard calling at night, concealed in rice paddies in Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). In the rainy season, adult frogs were occasionally collected and eaten by the local populations around the MNINR (Zogbassé et al., unpub. data).

### Hemisotidae

#### *Hemisis marmoratus* (Peters, 1854)

Marbled Piglet Frog

**Material:** Two males, NGK-Nimba 0085, NGK-Nimba 0089 (Fig. 8D). **Comments:** *Hemisis marmoratus* is a fossorial frog, very common in the savannah ecosystems of sub-Saharan Africa (Rödel 2000; Channing and Rödel 2019). We found it in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl), among short grasses at puddles, in leaf litter under cocoa and coffee trees, and around a manual hydraulic water pump. The body size of males ranged from 29.0–34.5 mm (N = 4), while females measured between 33.0–50.5 mm (N = 8).

### Hyperoliidae

#### *Afrixalus dorsalis* (Peters, 1875)

Striped Spiny Reed Frog

**Material:** Male, NGK-Nimba 0051 (Fig. 8E).

**Comments:** *Afrixalus dorsalis* is a nocturnal leaf-folding frog, which inhabits a wide range of western African habitats, such as savannah, farmbrush, and swampy areas at forest edges (Schjötz 1967; Rödel 2000; Channing and Rödel 2019). We heard many calling males in rice paddies and in grassy vegetation of swamps, in Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). A male measured 22.0 mm SUL.

#### *Afrixalus fulvovittatus* (Cope, 1861)

Banded Spiny Reed Frog

**Material:** Two females, NGK-Nimba 0066, NGK-Nimba 0067 (Fig. 8F). **Comments:** *Afrixalus fulvovittatus* can be easily recognized by its characteristic reddish-brown dorsal surface with three light longitudinal stripes joining on the tip of the snout. The delicate reddish-brown line

in the middle of each light stripe distinguishes it from the similar looking *A. vittiger* (Pickersgill 2007). This nocturnal species prefers the heavily degraded habitats of the forest zone (Schjötz 1967; Rödel and Glos 2019). In the Yéalé village, the species was found in rice paddies and grassy swamps (07°31.928'N, 008°25.401'W; 425 m asl). The SULs of two females were 19.8–21.0 mm, thus they were below the described size for *A. fulvovittatus* (Schjötz 1967).

#### *Hyperolius chlorosteus* (Boulenger, 1915)

Large Green Reed Frog

**Material:** Three males, NGK-Nimba 0075 (Fig. 8G), NGK-Nimba 0076 (Fig. 8H), NGK-Nimba 0088.

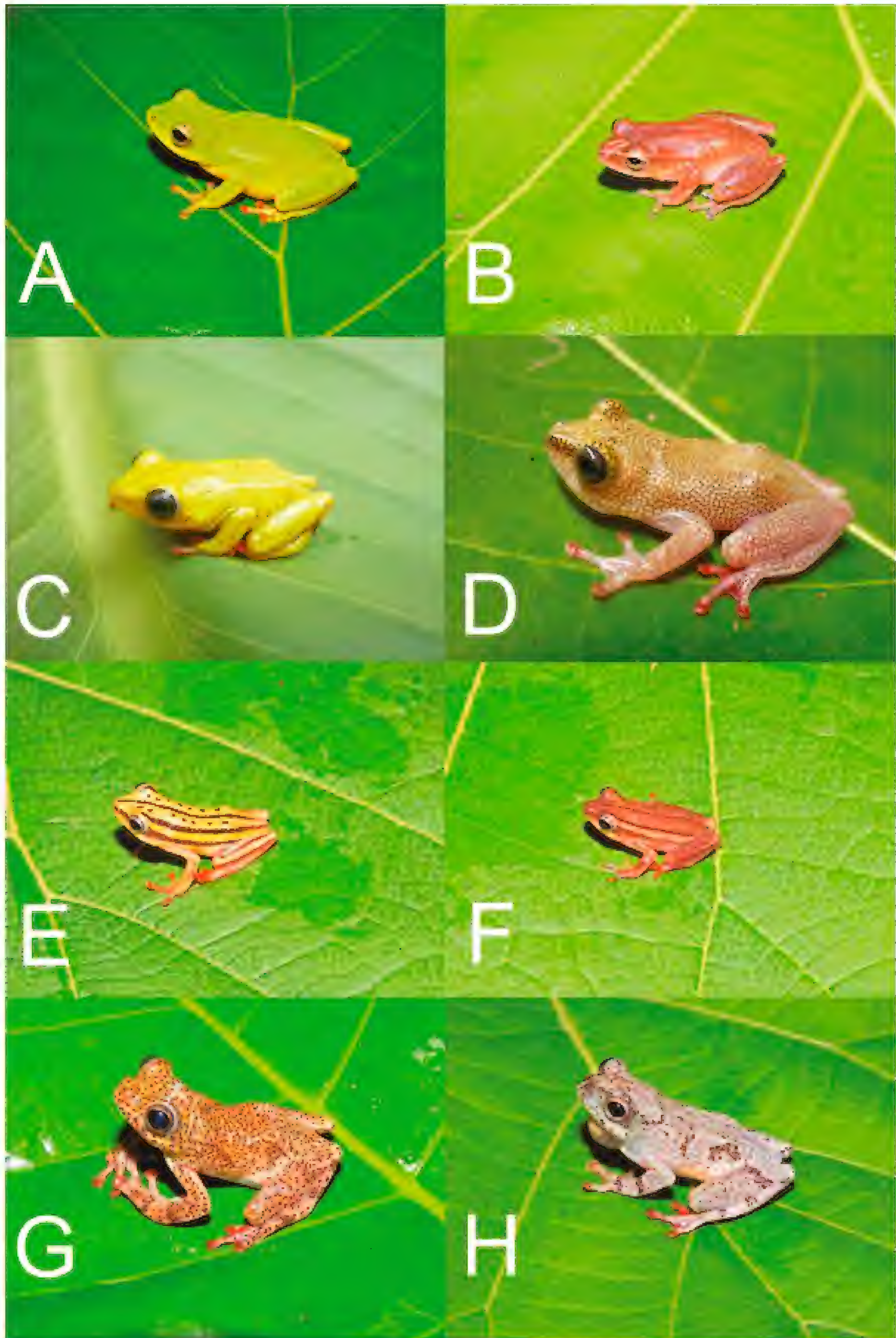
**Comments:** *Hyperolius chlorosteus* is common along streams in pristine forest from western Ivory Coast to Sierra Leone (Schjötz 1967; Channing and Rödel 2019). In Ivory Coast, it was reported from the rainforest zone, i.e., the Taï National Park (e.g., Schjötz 1967; Rödel et al. 2002), as well as from the edge of the forest zone in the Mount Sangbé National Park (Rödel 2003). Records from Mount Péko National Park (Rödel and Ernst 2003) and the Haute Dodo and Cavally forests (Rödel and Branch 2002) may no longer exist. Thus, our records of *H. chlorosteus* from Mounts Nimba, confirming the records by Schjötz (1967), show that the species prevailed, at least here, through the past 50 years. The species was frequently recorded at night along streams in the primary forest. After a heavy rainfall, a vast number of males (N > 50) were heard calling from high up in tall trees along a torrent stream (07°34.652'N, 008°24.966'W; 716 m asl). Five males were captured, and their body sizes ranged from 33.2–37.0 mm. They showed some variation of their back coloration, however, within the range known for the species (compare Schjötz 1967; Channing and Rödel 2019). We found one male in sympatry with *L. macrotis* in a degraded forest during the rainy season (07°31.932'N, 008°25.508'W; 387 m asl), perched up at approximately 1.80 m above the ground, close to a large stream. Most males, however, called from much higher sites.

#### *Hyperolius concolor* (Hallowell, 1844)

Uniform Reed Frog

**Material:** One female, NGK-Nimba 0011 (Fig. 9A), and two males, NGK-Nimba 0012 (Fig. 9B), NGK-Nimba 0020.

**Comments:** *Hyperolius concolor* is one of the most common West African frogs, widespread in a range of habitats from savannahs and farmbrush to degraded and gallery forests (Schjötz 1967; Rödel 2000). It even has been reported from urban sites (Kouamé et al. 2015). Calling males were abundant in rice paddies and grass-covered edges of ponds (07°31.928'N, 008°25.401'W; 425 m asl). The species is dichromatic (Portik et al. 2019), with females exhibiting a uniform light yellowish-green back with reddish toe discs (SUL: 32.0–33.0 mm, N = 2); males in contrast are brownish, often with some



**Fig. 9.** Hyperoliid frogs from Mount Nimba Integrated Nature Reserve: *Hyperolius concolor* female (A); *H. concolor* male (B); *H. fusciventris fusciventris* male (C); *H. guttulatus* female (D); *H. lamottei* female (E); *H. lamottei* male (F); *H. nimbae* female (G); *H. nimbae* male (H).

## Amphibians of the Nimba Mountains (Ivorian part)

dark patterns between the eyes and on the back (SUL: 23.5–25.5 mm, N = 5).

### *Hyperolius fusciventris fusciventris* Peters, 1876

Dark-bellied Reed Frog

**Material:** Male, NGK-Nimba 0077 (Fig. 9C).

**Comments:** *Hyperolius fusciventris fusciventris* occurs from western Ivory Coast into neighboring Liberia and Guinea in farmbush, heavily degraded forests, and occasionally in gallery forests within humid savannah (Schjøtz 1967). We encountered the species in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl), in an open but densely vegetated area close to swamps. The dorsal color varied from uniform brownish over light green to dense green. Some individuals with greyish-blue eyes exhibited a uniform yellow dorsal color. The belly of females was either dark or light grey. All males had a lighter belly. The male SULs ranged from 23.5–25.0 (N = 7), females reached 26.5–27.0 mm (N = 3).

### *Hyperolius guttulatus* Günther, 1858

Spotted Reed Frog

**Material:** Female, NGK-Nimba 0052 (Fig. 9D).

**Comments:** *Hyperolius guttulatus* lives in the humid savannah zone and clearings within rainforests (Schjøtz 1967; Rödel 2000; Assemian et al. 2006; Kouamé et al. 2015). The species usually reproduces in larger, permanent ponds with floating vegetation (Schjøtz 1967; Kouamé et al. 2015). We found five males calling at night between rice paddies around the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). A female measured 37.0 mm.

### *Hyperolius lamottei* Laurent, 1958

Lamotte's Reed Frog

**Material:** One female, NGK-Nimba 0074 (Fig. 9E), and two males, NGK-Nimba 0081 (Fig. 9F), NGK-Nimba 0082. **Comments:** *Hyperolius lamottei* is a savannah frog with a patchy distribution, preferring low grass habitats, often in higher altitude, e.g., granite inselbergs in central-southern Ivory Coast, Liberia, Guinea, Sierra Leone to Senegal (Arnoult and Lamotte 1958; Lamotte 1969, 1971; Schjøtz 1967; Rödel et al. 2004). Recently, it was reported for the first time from Burkina Faso (Ayoro et al. 2020). In Ivory Coast, the species was recorded from the Lamto Faunal Reserve (Schjøtz 1967) and the Mount Péko National Park (Rödel and Ernst 2003). However, more recently Adeba et al. (2010) failed to re-detect the species in Lamto. We found *H. lamottei* in large numbers in grassy montane pasture (07°35.258'N, 008°25.052'W; 821 m asl). The species was only active during the rainy season, when males and females became active after sunset. They spent the night perching on high grasses which covered a flooded iron-oxide quartzite ground. During the daytime all frogs hid within the dense herbaceous vegetation. Body size of males ranged from 17.5–19.0 mm (N = 4), females measured 21.5–23.5 mm

(N = 3). Color pattern was variable, but within the range described by Schjøtz (1967).

### *Hyperolius nimbae* Laurent, 1958

Nimba Reed Frog

**Material:** One female, NGK-Nimba 0070 (Fig. 9G),

and two males, NGK-Nimba 0078, NGK-Nimba 0079 (Fig. 9H). **Comments:** *Hyperolius nimbae* is a farmbush frog, endemic to the eastern foothills of Mounts Nimba (Schjøtz 1967). After 47 years, this species was only recently rediscovered by Kouamé et al. (2016), reporting small populations from four villages (Dagbonpleu, Danipleu, Kouan-Houlé, and Zéalé) within the formerly known range. An even more recent re-investigation in these villages failed to confirm the species, and its known habitats had been destroyed due to road expansions, development, and urbanization (Gongomin et al., unpub. data). However, during our study, we encountered a large number of *H. nimbae* males in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). The habitat was within a plantation of cocoa and coffee that edged a large and deep pond, which exceeded 100 x 70 m. There, we observed 15 males at night between broad leaved, evergreen trees of cocoa and coffee, while only one female was seen perched between the leaves of a palm tree. The males ranged from 30.0–35.5 mm (N = 15), the female measured 34.1 mm. Males varied considerably in color and also showed some differences in pattern compared to the female. However, both sexes matched earlier descriptions by Schjøtz (1967).

### *Hyperolius picturatus* Peters, 1875

Painted Reed Frog

**Material:** One female, NGK-Nimba 0104 (Fig. 10A),

and one male, NGK-Nimba 0105 (Fig. 10B). **Comments:** *Hyperolius picturatus* inhabits farmland and forest areas in various state of degradation, from central Ghana to Sierra Leone (Schjøtz 1967; Rödel 2000; Channing and Rödel 2019). We found the species in an agricultural area of the Yéalé village. The basic dorsal color of males (28.0–31.5 mm, N = 4) was brownish with two light, broad dorsolateral stripes, while the venter, including gular glands, was entirely yellow. A female (35.5 mm) had yellow, broad dorsolateral stripes with some small yellow spots on its black chin. Its venter likewise was bright yellow. This widespread taxon shows some color variation across its range and may comprise two species (Schjøtz 1967; Rödel and Branch 2002; Rödel and Glos 2019).

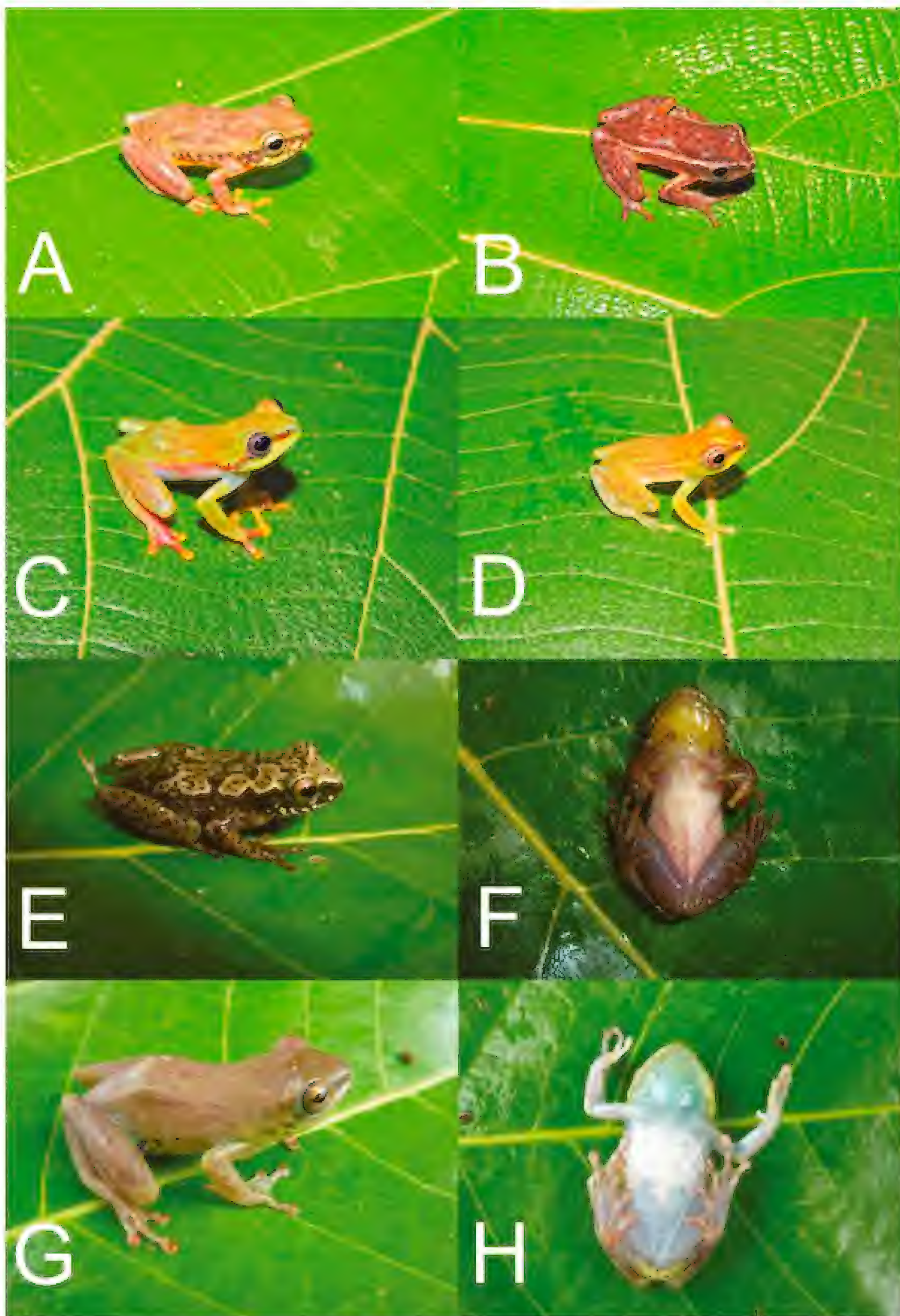
### *Hyperolius soror* (Chabanaud, 1921)

Soror Reed Frog

**Material:** One female, NGK-Nimba 0125 (Fig. 10C),

two males, NGK-Nimba 0126 (Fig. 10D), NGK-Nimba 0127. **Comments:** We heard over a dozen *H. soror* males calling during the rainy season in a dense grassy swamp, edging forest (07°32.993'N, 008°24.753'W; 425 m asl).





**Fig. 10.** Hyperoliid frogs from Mount Nimba Integrated Nature Reserve: *Hyperolius picturatus* female (A); *H. picturatus* male (B); *H. soror* female (C); *H. soror* male (D); *H. cf. sylvaticus* male (E); *H. cf. sylvaticus* male in ventral view (F); *H. sp.* male (NGK-Nimba 0068) (G); *H. sp.* male (NGK-Nimba 0068) in ventral view (H).

However, only one female and two males were caught there. The species is sexually dimorphic. The female (25.1 mm SUL) had a light green back, with diffuse, minute, reddish-brown spots, red lateral markings, a red stripe from snout to tip of eye, bluish-grey iris, and toes and fingers, including webbing, were faintly red with green tips. Its ventral surface was transparent bluish green. In contrast, both males (SUL 19.1 and 21.1 mm) had a golden iris, a dark red canthal stripe, green dorsum with diffuse, minute, reddish-brown spots, light dorsolateral stripes, and green toes and fingers.

***Hyperolius cf. sylvaticus* Schiøtz, 1967**

Forest Reed Frog

**Material:** Male, NGK-Nimba 0108 (Fig. 10E–F).

**Comments:** *Hyperolius cf. sylvaticus* was recorded in an open area in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). However, *H. sylvaticus* is known to be a forest species (Schiøtz 1967; Rödel and Branch 2002; Ernst and Rödel 2008), thus it might just as well be a member of the *Hyperolius picturatus*-complex.

***Hyperolius* sp.**

**Material:** Male, NGK-Nimba 0068 (Fig. 10G–H).

**Comments:** Two *Hyperolius* sp. were recorded in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl), in a swampy area with a shallow creek, dense herbaceous formations, and few shrubs and trees. A male (26.4 mm) possessed a uniform greyish-brown dorsal color; the throat was dull blue; the anterior part of the belly was white, the posterior part greenish to blueish. The ventral surfaces of limbs were greenish; the discs of toes and fingers were reddish. The gular gland was indistinct and smooth. So far, we cannot assign these frogs to any West African *Hyperolius* species (e.g., Schiøtz 1967; Channing and Rödel 2019). Molecular and acoustic data are required in order to resolve the taxonomic status of this reedfrog.

***Kassina cochranæ* (Loveridge, 1941)**

Cochran's Running Frog

**Material:** Four males, NGK-Nimba 0139, NGK-Nimba 0140, NGK-Nimba 0141 (Fig. 11A), NGK-Nimba 0142.

**Comments:** *Kassina cochranæ* is an arboreal forest and farmbush dweller, ranging from the rainforest edge into the moist savannah zone from western Ivory Coast to eastern Sierra Leone (Schiøtz 1967; Rödel et al. 2002). During the rainy season, we heard a vast number of males calling concealed in dense vegetation, close to a grassy swamp (habitat C: 07°32.993'N, 008°24.753'W; 425 m asl). Four males measured 34.0–36.5 mm. In the Yéalé village, a *K. cochranæ* metamorph was found by dip-netting in a deep pond in dense farmbush vegetation. At night, adult males were heard calling at the same site between inaccessible dense vegetation, edging a swamp (07°31.928'N, 008°25.401'W; 425 m asl).

**Odontobatrachidae**

***Odontobatrachus arndti* Barej, Schmitz, Penner, Doumbia, Sandberger-Loua, Emmrich, Adeba, and Rödel, 2015**

Arndt's Toothed Frog

**Material:** Three females, NGK-Nimba 0244, NGK-Nimba 0245, NGK-Nimba 0246, and two males, NGK-Nimba 0247 (Fig. 11A), NGK-Nimba 0248. **Comments:**

*Odontobatrachus arndti* is a torrent-frog living in primary and slightly degraded forests, known from Mount Sangbé and Mounts Nimba (Barej et al. 2015; Channing and Rödel 2019). We found a few populations of *O. arndti* along cascades of streams in forested ravines edged by savannah (07°35.233'N, 008°25.190'W; 847 m asl). These frogs were found to be very abundant along a very torrent stream (07°34.652'N, 008°24.966'W; 716 m asl). In a lower part of the forest, an additional site was along a wide torrent stream with a gravel bottom and blocks of granite rock (07°33.121'N, 008°25.036'W; 422 m asl). The recorded males exhibited huge bright orange femoral glands. They measured 45.1–52.5 mm (N = 8); the female SUL ranged from 43.5–60.5 mm (N = 10), thus the sizes of both sexes are within the known range of the species (Barej et al. 2015). At all sites, the majority of frogs were close to the rocky streams, however, a few females perched on trees close to the streams. These records are the second for Ivory Coast.

**Phrynobatrachidae**

***Phrynobatrachus alleni* Parker, 1936**

Allen's Puddle Frog

**Material:** Male, NGK-Nimba 0010 (Fig. 11C).

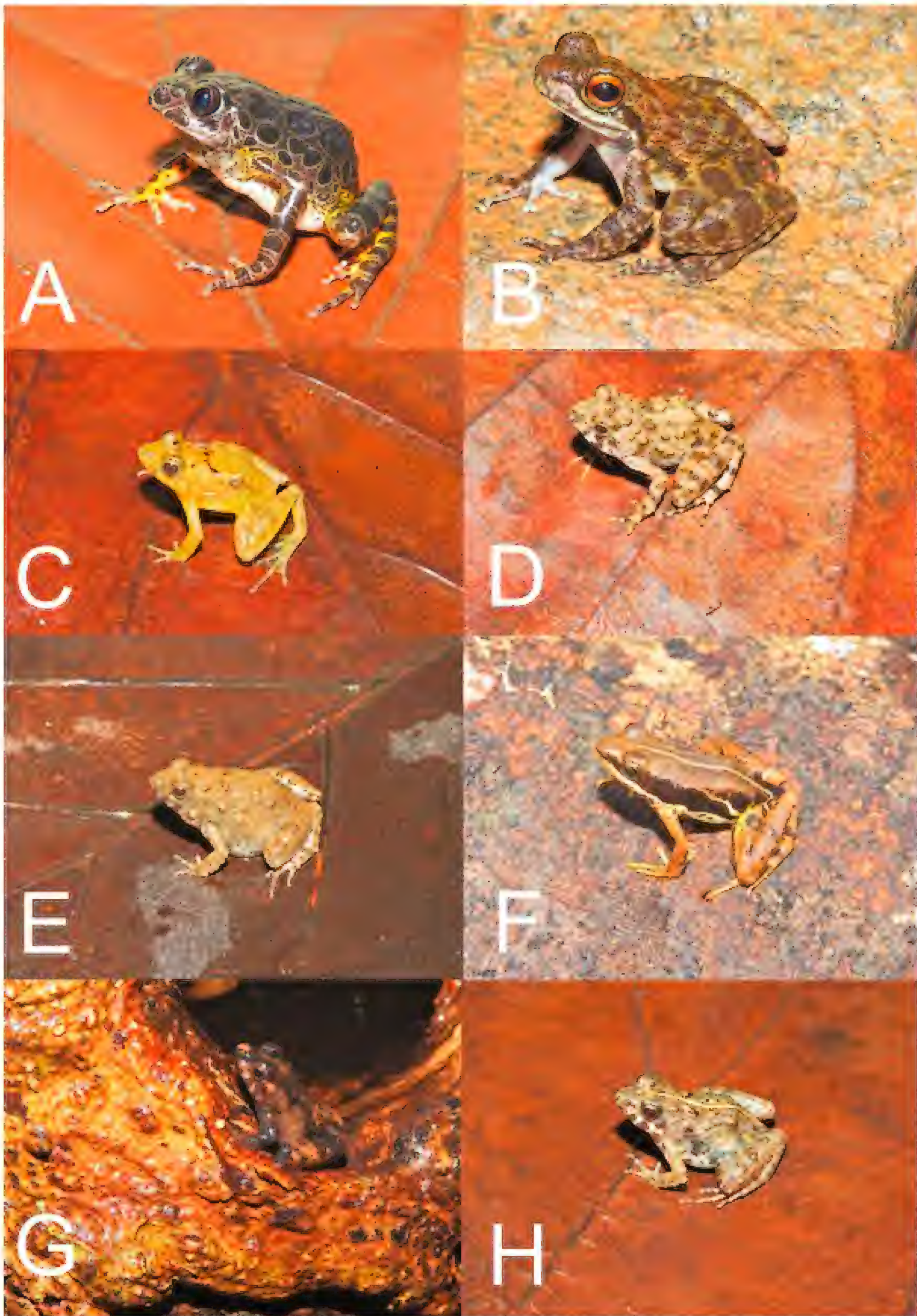
**Comments:** During the rainy season, we found a yellow *Phrynobatrachus alleni* male (18.5 mm) in breeding condition, among leaf litter on the forest floor, in a patch of dense forest, crossed by a small stream (07°32.993'N, 008°24.753'W; 425 m asl). Rödel (2003) reported from nearby Mount Sangbé that breeding *P. alleni* became completely yellow. The yellow color may disappear within minutes when the frogs are disturbed. In Taï National Park, breeding *P. alleni* males were never observed to be completely yellow (M.-O. Rödel, unpub. data).

***Phrynobatrachus annulatus* Perret, 1966**

Ringed Puddle Frog

**Material:** Two females, NGK-Nimba 0091 (Fig. 11D), NGK-Nimba 0094. **Comments:**

*Phrynobatrachus annulatus* is a forest-dwelling leaf litter frog, which has a patchy distribution in forests from south-eastern Guinea, eastern Liberia, western Ivory Coast, and western Ghana (Ernst and Rödel 2006; Hillers and Rödel 2007; Rödel et al. 2005; Rödel and Glos 2019). In Ivory Coast, the species was reported from Taï National Park (e.g., Ernst and Rödel 2006; Hillers et al. 2008c), and the Mabi-Yaya



**Fig. 11.** Hyperoliid, odontobatrachid, and phrynobatrachid frogs from Mount Nimba Integrated Nature Reserve: *Kassina cochranae* male (A); *Odontobatrachus arndti* male (B); *Phrynobatrachus alleni* male (C); *P. annulatus* male (D); *P. francisci* female (E); *P. fraterculus* female (F); *P. guineensis* male (G); *P. gutturosus* female (H).

## Amphibians of the Nimba Mountains (Ivorian part)

Forest Reserve (Gongomin et al. 2019). We found two young females of *P. annulatus* (14.0 and 20.2 mm) in a site with high canopy forest on the slopes of a large granite inselberg. The dry forest ground was covered with multiple layers of leaf litter, but the undergrowth was sparse (07°34.364'N, 008°24.746'W; 643 m asl). Drier parts of the forest along slopes of inselbergs also comprise the usual habitat where this species was recorded in Taï National Park (M.-O. Rödel, unpub. data).

### *Phrynobatrachus francisci* Boulenger, 1912

Francisc's Puddle Frog

**Material:** Two females, NGK-Nimba 0092 (Fig. 11E), NGK-Nimba 0093. **Comments:** *Phrynobatrachus francisci* occurs in moist Guinea savannah and drier Sudanese savannah, from Senegal to Nigeria (Rödel 2000; Channing and Rödel 2019). We found the species in the rainy season, among dense herbaceous vegetation at the edge of a puddle (07°31.928'N, 008°25.401'W; 425 m asl). Two females (20.5–22.0 mm) were caught in the Yéalé village during late afternoon (1618 h GMT).

### *Phrynobatrachus fraterculus* (Chabanaud, 1921)

Brother's Puddle Frog

**Material:** Female, NGK-Nimba 072 (Fig. 11F). **Comments:** *Phrynobatrachus fraterculus* is known to inhabit degraded forest and forest edges in the western part of the Upper Guinea forest region (Guibé and Lamotte 1963; Rödel and Bangoura 2004; Rödel and Glos 2019). A female (24.0 mm) was found in leaf litter near a shallow creek in a small clearing (07°33.121'N, 008°25.036'W; 422 m asl). In Ivory Coast, the species had been recorded previously in the Taï National Park (Ernst and Rödel 2006; Hillers et al. 2008c).

### *Phrynobatrachus guineensis* Guibé and Lamotte, 1962

Guinea Puddle Frog

**Material:** Male, NGK-Nimba 0034 (Fig. 11G). **Comments:** *Phrynobatrachus guineensis* is the only known West African member of its genus that uses water-filled tree holes as breeding sites (Rödel 1998; Rödel et al. 2004; Rudolf and Rödel 2007). A breeding male (15.5 mm) was found in a water-filled tree hole in a patch of dense forest (07°34.696'N, 008°25.015'W; 717 m asl).

### *Phrynobatrachus gutturossus* (Chabanaud, 1921)

Guttural Puddle Frog

**Material:** Two females, NGK-Nimba 0095 (Fig. 11H), NGK-Nimba 0096, and two males, NGK-Nimba 0097, NGK-Nimba 0098. **Comments:** A complex of cryptic West African puddle frogs is currently known under the name *Phrynobatrachus gutturossus* (Rödel 2000; Zimkus et al. 2010). One species of that complex, *P. afiabirago*, has been recently described from southern Ghana (Ofori-Boateng et al. 2018). Frogs from this complex became known from primary rainforest to dry savannah habitats

(Rödel 2000; Rödel and Spieler 2000; Ernst and Rödel 2006; Nago et al. 2006; Hillers et al. 2008c), and their taxonomic status requires further research. We found *P. gutturossus* among leaf litter in a cocoa and coffee plantation (07°31.928'N, 008°25.401'W; 425 m asl). The plantation comprised a large pond and was used by people from the Yéalé village to grow rice. Numerous individuals of *P. gutturossus* were seen after sunset (1830 h GMT). Two females measured 18.5 and 20.0 mm.

### *Phrynobatrachus latifrons* Ahl, 1924

Savannah Puddle Frog

**Material:** One female, NGK-Nimba 0064 (Fig. 12A), and one male, NGK-Nimba 0065 (Fig. 12B). **Comments:** *Phrynobatrachus latifrons* is a very common and widespread, semi-aquatic West African puddle frog, living in savannah and heavily degraded rainforest habitats (Rödel 1995 [there erroneously termed *P. francisci*], 2000; Kouamé et al. 2018). The species was abundant in the Yéalé village. In particular, we heard males calling between densely vegetated parts of swamps and paddy fields (07°31.928'N, 008°25.401'W; 425 m asl). An adult female with a broad green back and a light vertebral line exhibited an unusual thin, light longitudinal line on upper surface of the tibia (22.0 mm). A uniform brown frog (18.1 mm) exhibited the bright yellow throat, typical for adult males.

### *Phrynobatrachus liberiensis* Barbour and Loveridge, 1927

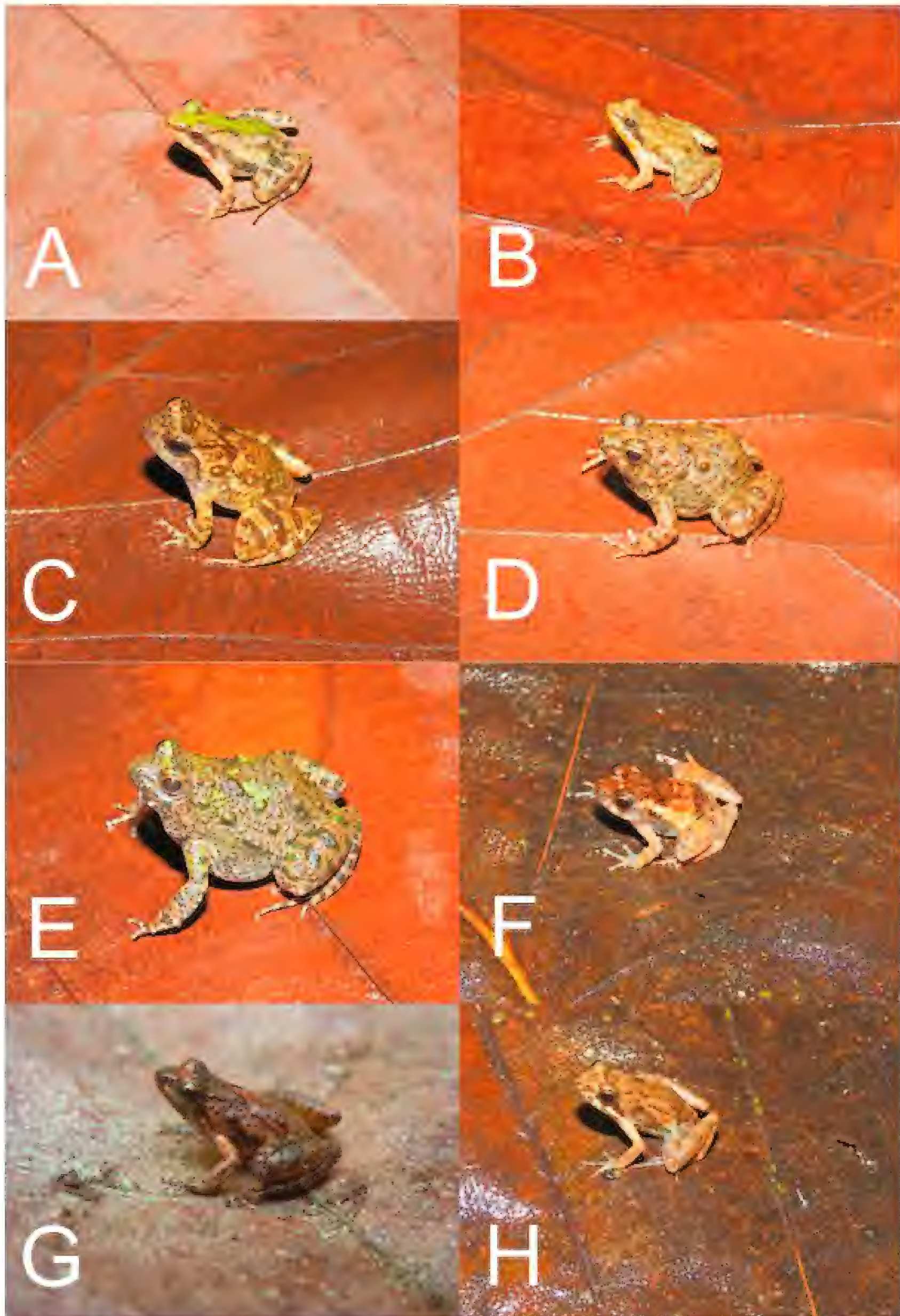
Liberian Puddle Frog

**Material:** Male, NGK-Nimba 0071 (Fig. 12C). **Comments:** *Phrynobatrachus liberiensis* is generally found along swamps and shallow streams in primary forests (Rödel and Branch 2002; Kouamé et al. 2018). Many males were heard calling, being well concealed sitting on the banks of a shallow stream in a swampy patch of dense forest (07°32.993'N, 008°24.753'W; 425 m asl). A male (27.0 mm) and a young female (26.0 mm) were caught.

### *Phrynobatrachus natalensis* (Smith, 1849)

Natal Puddle Frog

**Material:** Two males, NGK-Nimba 0032 (Fig. 12D), NGK-Nimba 0033, and two females, NGK-Nimba 0035, NGK-Nimba 0036 (Fig. 12E). **Comments:** *Phrynobatrachus natalensis* as currently defined (Channing and Rödel 2019) comprise several cryptic species widespread throughout the savannah areas of sub-Saharan Africa (Zimkus et al. 2010). We encountered the species in the Yéalé village, near road puddles in dense vegetation (07°31.928'N, 008°25.401'W; 425 m asl). Other active males were found at night between tufts of ornamental plants around houses after heavy rainfalls. Adult males were uniform brown (26.0–28.1 mm; N = 6) and had black throats with folds, while adult females (27.8–33.5 mm; N = 8) had white, mottled



**Fig. 12.** Phrynobatrachid frogs from Mount Nimba Integrated Nature Reserve: *Phrynobatrachus latifrons* female (A); *P. latifrons* male (B); *P. liberiensis* male (C); *P. natalensis* male (D); *P. natalensis* female (E); *P. phyllophilus* male (F); *P. tokba* female (G); *P. tokba* male (H).

brown or greyish-black throats. One female exhibited an exceptionally conspicuous greyish-brown back with green spots and a green interorbital line; other females being uniform brown. Some frogs reproduced in a large pond within dense vegetation. Four clutches comprising, 938, 1021, 1265, and 1501 small reddish-brown eggs, were floating on the water surface. Mean egg diameter was 0.9 mm ( $\pm$  0.1 mm; N = 20). Clutch sizes therefore seem to be larger in West African, compared to southern African, populations (compare values in Rödel 2000).

***Phrynobatrachus phyllophilus* Rödel and Ernst, 2002**

Leaf-loving Puddle Frog

**Material:** Male, NGK-Nimba 0037 (Fig. 12F).

**Comments:** *Phrynobatrachus phyllophilus* prefers patches of swampy primary forest from eastern Ivory Coast to Sierra Leone (Rödel and Ernst 2002a; Ernst and Rödel 2006; Kouamé et al. 2008, 2014, 2018; Channing and Rödel 2019). We found only one male (15.0 mm) during the rainy season. It was concealed among dense leaf litter, in a patch of dense forest, intersected by a small stream (07°32.993'N, 008°24.753'W; 425 m asl).

***Phrynobatrachus tokba* (Chabanaud, 1921)**

Tokba Puddle Frog

**Material:** Female, NGK-Nimba 0038 (Fig. 12G).

**Comments:** *Phrynobatrachus tokba* occurs in primary to degraded forests, and montane grassland, from western Guinea to Ghana (Guibé and Lamotte 1963; Rödel et al. 2004, 2005; Kouamé et al. 2018; Channing and Rödel 2019). This species reproduces terrestrially, by depositing clutches in moist leaves, and has non-feeding, non-hatching tadpoles (Rödel and Ernst 2002b). A large number of *P. tokba* males called in the drier part of the forest. A brown female measured 18.0 mm. Further populations were detected in moist savannah adjacent to forest, and even in sympatry with *Nimbaphrynoides occidentalis* up to 1,235 m asl in montane grasslands (07°35.555'N, 008°25.788'W; Fig. 12H).

**Pipidae**

***Xenopus tropicalis* (Gray, 1864)**

Tropical Clawed Frog

**Material:** Two females, NGK-Nimba 0001 (Fig. 13A), NGK-Nimba 0002, and two males, NGK-Nimba 0003, NGK-Nimba 0006. **Comments:** This pipid lives in forests, degraded forests, and gallery forests in humid savannahs from Senegal to western Cameroon (Rödel 2000). The species was seen in flooded paddy fields in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). In the dry season, frogs were easily caught in patches of the same shallow swamps. Some juvenile frogs measured 21.5–30.0 mm (N = 5), adult males reached 32.4–42.5 mm (N = 5), and adult females ranged from 48.3–53.3 mm (N = 4).

**Ptychadenidae**

***Ptychadena arnei* Perret, 1997**

Schiøtz's Grass Frog

**Material:** Male, NGK-Nimba 0053 (Fig. 13C).

**Comments:** *Ptychadena arnei* is a poorly studied frog occurring in humid savannahs, secondary forests, and gallery forests, from southern Senegal to central Ivory Coast (Channing and Rödel 2019). Only two females (43.5 and 45.5 mm) and two males (39.5 and 40.5 mm) were recorded at night in the Yéalé village, sitting at the edge of a road puddle that intersected a heavily degraded forest. The basic color of their back was brown to grey with a light triangle on the snout. *Ptychadena oxyrhynchus*, which often have a pale snout as well, have much longer legs (see e.g., Fig. 13F). The *P. arnei* specimens had short dorsolateral folds and possessed distinct sacral folds. They had dark to pale crossbars on the legs and lacked external metatarsal tubercles. A female (Fig. 13B) exhibited a fine yellow vertebral line. A reddish to yellow longitudinal line on the tibia was broad towards the heel, but narrow towards the knee. The upper part of flanks was reddish, while the lower part was grey with black spots. The ventral surface ranged from whitish through beige to yellow. The species is known by its unique advertisement calls, which consist of a long succession of short double calls (Channing and Rödel 2019). In paddy fields around Daloa, western-central Ivory Coast, frogs that were morphologically identical emitted such calls (Kouamé et al., unpub. data).

***Ptychadena bibroni* (Hallowell, 1845)**

Bibron's Grass Frog

**Material:** One female, NGK-Nimba 0104 (Fig. 13D), and one male, NGK-Nimba 0105. **Comments:** We found *P. bibroni* in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl) along road puddles during the rainy season, and in cocoa and coffee plantations during the dry season. This frog is known from humid savannahs, but was also reported from dry savannahs and open degraded forests (Rödel 2000; Channing and Rödel 2019). The body size of males ranged from 39.0–46.0 mm (N = 6), while females reached 46.5–57.0 mm (N = 7).

***Ptychadena longirostris* (Peters, 1870)**

Snouted Grass Frog

**Material:** Female, NGK-Nimba 0039 (Fig. 13E).

**Comments:** *Ptychadena longirostris* was found along a forest trail with puddles of various sizes (07°32.993'N, 008°24.753'W; 425 m asl). They had a yellowish back with an ill-defined darker lateral band, stretching from the nares through eyes, tympanum, and flanks to the groin. The size of males ranged from 43.0–46.0 mm (N = 4); two females measured 50.0 and 52.5 mm (N = 2). This West African species is known to breed in puddles along forest roads (Guibé and Lamotte 1954; Rödel



**Fig. 13.** Pipid and ptychadenid frogs from Mount Nimba Integrated Nature Reserve: *Xenopus tropicalis* female (A); *Ptychadena arnei* female (B); *P. arnei* male (C); *P. bibroni* male (D); *P. longirostris* male (E); *P. oxyrhynchus* male (F); *P. pujoli* male (G); *P. pumilio* female (H).

2000). It preys on various insects and occasionally even aquatic food items (Konan et al. 2016).

***Ptychadena oxyrhynchus* (Smith, 1849)**

Sharp-nosed Grass Frog

**Material:** Two females, NGK-Nimba 0040, NGK-Nimba 0041, and one male, NGK-Nimba 0042 (Fig. 13F). **Comments:** *Ptychadena oxyrhynchus* is a large frog with extremely robust and long hind legs. It occurs in savannahs and edges of the forest zone across sub-Saharan Africa (Rödel 2000; Channing and Rödel 2019). During the rainy season, the species was found in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl), along dirt roads with temporary water bodies of different sizes. The species survives the dry season in humid parts of rice paddies. In this season, rice is harvested and we saw the frogs in vast numbers. The sizes of two females were 59.0 and 64.8 mm, while a male measured 52.0 mm.

***Ptychadena pujoli* (Lamotte and Ohler, 1997)**

Pujol's Grass Frog

**Material:** Male, NGK-Nimba 0045 (Fig. 13G). **Comments:** The biology of *Ptychadena pujoli* is very insufficiently known. It seems to occur in savannah swamps and grassland habitats from eastern Sierra Leone, through the Upper Guinea highlands, to western Ivory Coast (Lamotte and Ohler 1997; Channing and Rödel 2019). After a heavy rainfall, some migrating individuals were found among short grasses near houses in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). A male (48.5 mm SUL) with a brownish-grey back had a beige vertebral band. Its back was smooth to slightly granular. Flanks were light with some large warts. The animal had continuous light-colored external folds and distinguishable sacral folds. Its legs exhibited greyish dark crossbars, and its feet lacked metatarsal tubercles. The venter was yellowish. This species lived in syntopy with *P. arnei* in rice paddies around villages in the Daloa region (Kouamé et al., unpub. data).

***Ptychadena pumilio* (Boulenger, 1920)**

Western Dwarf Grass Frog

**Material:** Female, NGK-Nimba 0069 (Fig. 13H). **Comments:** A female *P. pumilio* was recorded in an open area with a shallow but densely vegetated pond near the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). The species is known from a wide range of habitats from humid to dry savannahs, to open areas in degraded forests, and ranges from southern Mauritania through the savannah belt to eastern Africa (Rödel 2000; Onadeko and Rödel 2008; Padial et al. 2008; Adeba et al. 2010; Channing and Rödel 2019).

***Ptychadena retropunctata* (Angel, 1949)**

Nimba Grass Frog

**Material:** Two males, NGK-Nimba 0060, NGK-Nimba 0061, and two females, NGK-Nimba 0062, NGK-Nimba

0063 (Fig. 14A). **Comments:** Five *P. retropunctata* were recorded on a high plateau with predominantly grassy mountain pastures and herbaceous vegetation (07°35.453'N, 008°24.957'W; 843 m asl). The SULs of males varied from 28.0–30.5 mm (N = 3), while two females measured 29.0 and 37.5 mm. Whereas four frogs were rust-colored, a female had a deep brown dorsum. In contrast to Rödel (2000) and Channing and Rödel (2019), who describe a white venter, our specimens had a yellow venter. The species was described previously from Mounts Nimba (Angel 1949). Further records became known only from a few montane localities in southeastern Guinea (summarized in Rödel et al. 2004), the Loma Mountains in Sierra Leone (Lamotte 1971), northern Guinea (Hillers et al. 2006), and southeastern Senegal (Monasterio et al. 2016). This is the first country record for *P. retropunctata* in Ivory Coast.

***Ptychadena stenocephala* (Boulenger, 1901)**

Narrow-headed Grass Frog

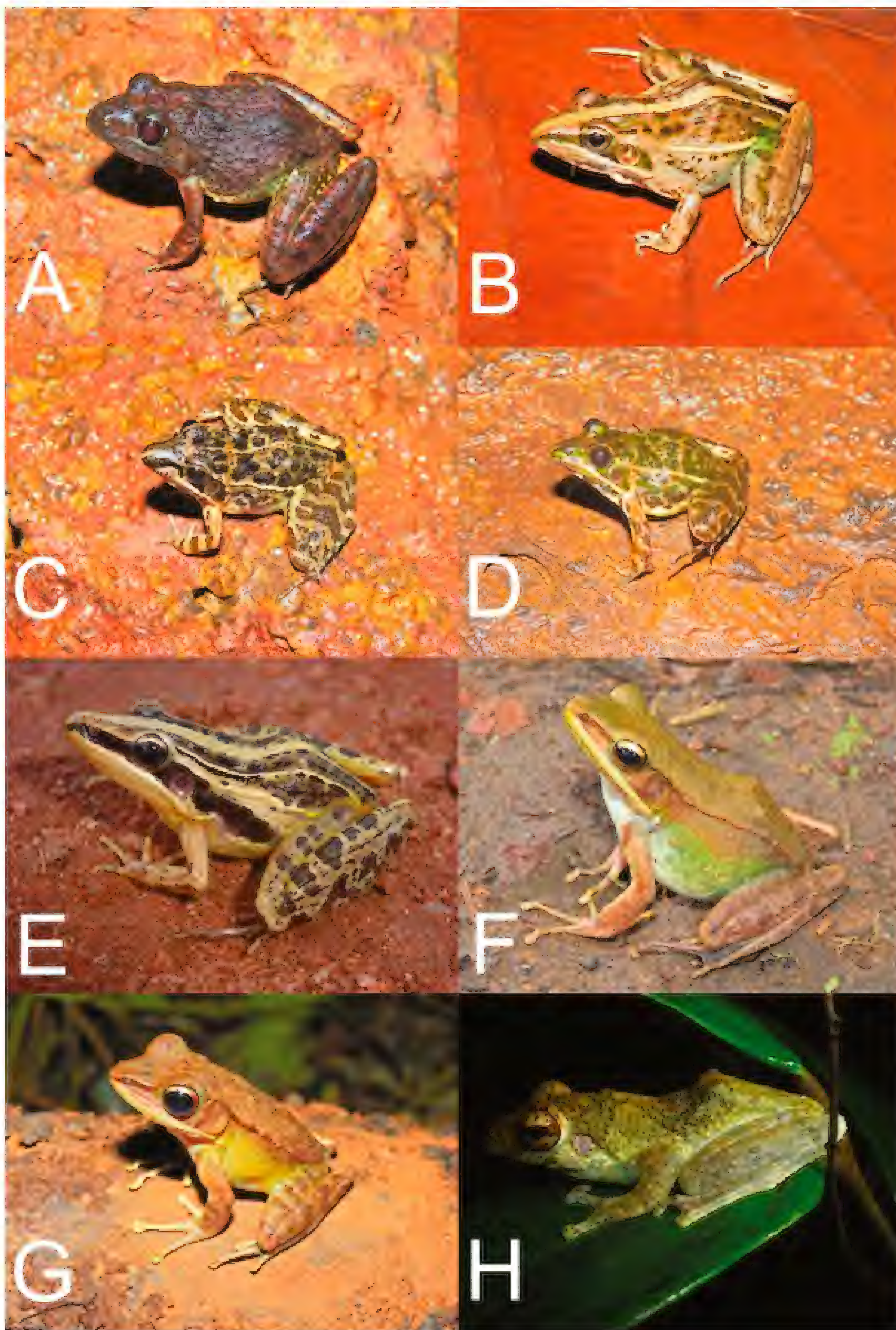
**Material:** Two females, NGK-Nimba 0030, NGK-Nimba 0100 (Fig. 14B). **Comments:** Two females of the *Ptychadena stenocephala*-complex (Rödel and Channing 2019) have been found at the edge of a roadside puddle near a heavily degraded forest in the Yéalé village (07°31.928'N, 008°25.401'W; 425 m asl). While they superficially resemble *P. mascareniensis*, e.g., by the ridges and a similar vertebral band (see e.g., Rödel and Glos 2019), they differ from the latter species by reduced webbing, and much more slender body shape (Channing and Rödel 2019). The exact taxonomic status of these frogs requires further research.

***Ptychadena submascareniensis* (Guibé and Lamotte, 1953)**

Small Grass Frog

**Material:** Three females, NGK-Nimba 0044, NGK-Nimba 0046, NGK-Nimba 0047 (Fig. 14C), and two males, NGK-Nimba 0048, NGK-Nimba 0049 (Fig. 14D). **Comments:** We found a large population of *P. submascareniensis* in predominantly grassy mountain pastures with herbaceous vegetation (07°35.453'N, 008°24.957'W; 843 m asl). There, the species occurred in vast numbers (> 1,500 individuals in an area of approximately 50 ha) during the rainy season. Calling males were observed during the day with peaks between 0830–1030 h GMT and 1830–2000 h GMT. The weather conditions during these observations were characterized by low visibilities due to mist and windy weather. We recorded two migrating individuals in montane grassland in sympatry with *A. cruscolum* and *N. occidentalis* (07°35.555'N, 008°25.788'W; 1,235 m asl). These rarely documented frogs (compare Guibé and Lamotte 1953, 1958a; Rödel and Bangoura 2004) have a compact body with a moderately pointed snout. Adult females measured 29.5–32.0 mm (N = 8), while males ranged from 24.0–





**Fig. 14.** Ptychadenid, ranid, and rhacophorid frogs from Mount Nimba Integrated Nature Reserve: *Ptychadena retropunctata* (A); *P. stenocephala* female (B); *P. submascareniensis* female (C); *P. submascareniensis* male (D); *P. tournieri* female (E); *Amnirana* sp. 'albolabris west' female (F); *Amnirana* sp. 'albolabris west' male (G); *Chiromantis rufescens* male (H).

27.5 mm (N = 18). According to Channing and Rödel (2019), Mount Nimba is the only known Ivorian site to host *P. submascareniensis*.

### ***Ptychadena tournieri* (Guibé and Lamotte, 1955)**

Tournier's Grass Frog

**Material:** Two females, NGK-Nimba 0054, NGK-Nimba 0055 (Fig. 14E), and one male, NGK-Nimba 0056. **Comments:** *Ptychadena tournieri* is widespread in patches of humid and dry savannahs from Senegal into Benin (Rödel 2000; Nago et al. 2006; Adeba et al. 2010; Channing and Rödel 2019). We found the species in open areas, most often among grasses at the edge of plantations. One male measured 35.0 mm, while three females ranged from 39.0–49.0 mm.

## **Ranidae**

### ***Amnirana* sp. 'albolabris-West'**

West African White-lipped Frog

**Material:** Female, NGK-Nimba 0101 (Fig. 14F). **Comments:** *Amnirana* sp. 'albolabris-West' is a forest-dwelling frog occurring in the Upper Guinean zone, formerly regarded as being conspecific with the real *A. albolabris* from Central African forests (Jongsma et al. 2018). While its description is being prepared, the occurrence of this species has been even more recently confirmed for Burkina Faso (Ayoro et al. 2020). This taxon was recorded in the Yéalé village, where a chorus was heard at night in a densely vegetated swampy area. One to two males initiated calling and many other males then joined the chorus. A similar behavior was also observed in *A. fonensis* (Kouamé et al., unpub. data). In the Yéalé village, frogs belonging to *A.* sp. 'albolabris-West' were also found in large numbers (N > 50) in a cocoa and coffee plantation near a large pond. Females had a less spiny back than males (Fig. 14G).

## **Rhacophoridae**

### ***Chiromantis rufescens* (Günther, 1869)**

Western Foam-nest Frog

**Material:** Male, NGK-Nimba 0102 (Fig. 14H). **Comments:** *Chiromantis rufescens* is a complex of treefrog species (Leaché et al. 2019), occurring in rainforest and the transition zone between forest and savannah, from West and Central Africa to the southernmost record in Angola (Lamotte 1967; Schiøtz 1967; Channing and Rödel 2019; Rödel and Glos 2019; Ernst et al. 2020). They are the only West African species depositing foam nests above stagnant waters (Coe 1967, 1974; Schiøtz 1967; Monayong Ako'o 1978; Rödel et al. 2002). During the entire survey in Mounts Nimba, only one specimen was found on a dark night in a plantation from the Yéalé village dominated by cocoa and coffee trees (Fig. 14H). This specimen measured 45.0 mm in SUL.

## **Discussion**

The amphibian fauna of the Nimba Mountains ranks among the best-known amphibian faunas in West Africa. However, our knowledge is almost completely based on records from the Guinean and Liberian parts of this mountain range (e.g., Guibé and Lamotte 1958a,b, 1963; Xavier 1978; Rödel et al. 2009, 2010; Sandberger et al. 2010; Sandberger-Loua et al. 2018a; Schäfer et al. 2019). Here, we present for the first time a comprehensive summary of the amphibian fauna of the Ivorian part of the mountains.

Such a summary is particularly pressing as the Nimba Mountains, with about 65 amphibian species recorded so far, comprise the most species-rich amphibian site in West Africa (summarized in Rödel et al. 2004; Barej et al. 2015; Schäfer et al. 2019; Channing and Rödel 2019; and several unpublished records), but it is also highly threatened by several factors. The Liberian part had been mined already in the last century (Lamotte 1983), the Guinean part has been prospected for mining and mining will be implemented there soon (J. Doumbia, pers. comm.). In the Ivorian part, natural forest and savannah habitats in the lowlands are imperiled by agricultural encroachment (Woods 2003), and mid-elevation and mountain grasslands are prone to the uncontrolled spread of bush-fires (Lamotte 1959; Hillers et al. 2008b; Sandberger-Loua et al. 2016; this study). Thus, it is important to understand the distributions of species, in particular the endemic and threatened species, of the amphibian fauna.

During our survey we detected 53 amphibian taxa. The smooth skinned, mid-sized squeaker frogs of the *Arthroleptis poecilnotus*-complex likely comprise several species (Rödel and Bangoura 2004), potentially including *A. nimbaensis*. Species which are important finds in this study are *Nimbaphrynoides occidentalis*, *Arthroleptis cruscolum*, *Hyperolius nimbae*, *H. soror*, *H. sp.*, and *Kassina cochranæ*, as well as several *Ptychadena* spp. (*arnei*, *pujoli*, *retropunctata*, and *submascareniensis*). These species all have limited ranges in the western part of the Upper Guinea biodiversity hotspot, where at least two of them, *Nimbaphrynoides occidentalis* and *Hyperolius nimbae*, are endemic to the Nimba Mountains (Channing and Rödel 2019)—the first to the montane grasslands and the second to the Ivorian foothills of the mountain. The montane and mid-elevation savannah grasslands of the MNINR are the only known and remaining Ivorian habitats for *N. occidentalis*, *P. retropunctata*, and *P. submascareniensis*. Sandberger-Loua et al. (2016) have shown that *N. occidentalis* comprises three isolated populations, two in Guinea and one in Liberia, however, there is some gene flow (Sandberger-Loua et al. 2018b). So far, it is unclear if the Ivorian records comprise a fourth population or (more likely) are sub-populations of the Guinean populations. Their habitats, the montane grasslands, are

facing the uncontrolled spread of bush-fires. In lowland habitats, human encroachments, forest fragmentation, and steadily increasing agricultural activities, and thus most likely a variety of agrochemicals, are crucial threats for other amphibian species such as *H. nimbae*. However, large areas of dense, broadleaf and evergreen forests, stretching from the lower to mid-elevation slopes, still prevail in MNINR (Fig. 4). Fourteen species, which became known from the Guinean and Liberian parts of the Nimba mountains, could not be detected in this study: *Arthroleptis krokosua*, *A. langeri*, *Sclerophrys chevalieri*, *Afraxalus weidholzi*, *Hyperolius zonatus*, *Phlyctimantis boulengeri*, *Phrynobatrachus calcaratus*, *P. hieroglyphicus*, *P. maculiventris*, *Ptychadena superciliaris*, *P. aff. aequiplicata*, *Odontobatrachus natator*, *Amnirana occidentalis*, *Geotrypetes pseudoangeli*, and *G. seraphini*. One further species, *Kassina lamottei*, was reported previously from the Ivorian Nimba area, but likewise could not be recorded here. The latter species seems to require large pristine lowland rainforests and reproduces in larger, stagnant ponds (but not in rivers or puddles). In Taï National Park, it was one of the most sensitive species concerning forest alteration (Rödel and Ernst 2001a; Ernst and Rödel 2005; Ernst et al. 2006).

For most of these species, our searching methods, which included acoustic sampling, should be efficient, as shown by our estimation curves indicating sufficient sampling effort for the species richness that occurs in the Ivorian sector of Mounts Nimba. Additionally, many species are more readily detected by their calls than sight, and as frogs were not active at all times, most of them are naturally rare and hide well, and thus are difficult to detect. Some may have escaped our attention in the field, e.g., tree-frogs hiding in the canopy. In order to find caecilians, which mainly live underground, we would have needed to dig in the most promising habitats. However, it is absolutely possible that at least some of these species are absent from the Ivorian slopes of the mountain. For instance, *Arthroleptis langeri* is only known from a few individuals of the Guinean part of Mount Nimba and isolated populations in Liberia (Nopper et al. 2012), while *Phrynobatrachus maculiventris* has been confirmed from a few sites in Guinea and Liberia (Rödel et al. 2009), and *P. hieroglyphicus* is only known from the type specimen and a locality in Liberia (Rödel et al. 2010). However, some other species, like *Phlyctimantis boulengeri*, are known to occur even in disturbed habitats (Rödel and Ernst 2001b, 2003), and thus were expected to occur in MNINR as well. Likewise, our search for *Kassina lamottei* in Zéalé, a formerly known Ivorian lowland locality from the eastern flanks of Mounts Nimba (Schlötz 1967), remained unsuccessful (NG Kouamé et al., unpub. data). There, primary forest has been cleared completely and new asphalted concrete roads facilitate commerce between Ivory Coast and Guinea (NG Kouamé, pers. obs.).

With 53 amphibian taxa, the MNINR is less diverse compared to the known species records in the Guinean part of the Nimba Mountains (Guibé and Lamotte 1958a,b, 1963; Xavier 1978; Rödel et al. 2009, 2010; Sandberger et al. 2010; Sandberger-Loua et al. 2018a; Schäfer et al. 2019). However, the Guinean part has a much larger area (12,540 ha) with a broader range of forested habitats, thus representing the most significant part of the Nimba mountain chain. As part of a set of discontinuous montane reliefs, the Upper Guinea mountain ranges extend along a northwest-southeast line from the Fouta Djallon massif in western Guinea to the regions of Danané and Man in Ivory Coast. The western slopes of these mountains generally receive higher precipitation than the eastern slopes (Rödel and Bangoura 2004; Lauginie 2007; Sandberger-Loua et al. 2017). As a consequence, the Ivorian slopes comprise more savannah patches. This may also explain the restriction of *H. nimbae* to the eastern slopes, as this reedfrog seems to prefer the transition zone between forest and savannah (Kouamé et al. 2016; this study). Nevertheless, when comparing various amphibian assemblages, both Nimba slopes share the highest faunal similarity in the region (comparing Table 3 and Appendix). Compared with other nearby sites, the amphibian species richness of MNINR is also higher than those of Mount Sangbé National Park (Rödel 2003), Diécké Forest Reserve (Rödel et al. 2004), Ziama Forest (Chabanaud 1920, 1921; Böhme 1994a, 1994b), and the Pic de Fon-Simandou range (Parker 1936; Taylor 1968; Rödel and Bangoura 2004). Still, MNINR shares a high number of amphibian species (48–72%) with these sites. Interestingly two range restricted species, e.g., *Conraua cf. alleni* (Fig. 8A–B) and *Odontobatrachus arndti* (Fig. 11B), are known from the Guinean part of Mounts Nimba (Barej et al. 2015; Schäfer et al. 2019), the MNINR (this study), and the adjacent Mount Sangbé National Park (Rödel 2003). This may indicate an area of unique amphibian composition. For instance, the *Conraua* spp. from Mount Sangbé, and potentially those from MNINR, differ in call characteristics from those in more southern Ivorian localities (Rödel and Branch 2002; M.-O. Rödel, unpub. data). The cryptic reedfrog, *Hyperolius* sp. (Fig. 10G–H), needs further investigation because it may represent an undescribed species. Compared with other pristine forest areas, the species richness of MNINR is in the range of Taï National Park in southwestern Ivory Coast (Rödel and Ernst 2004; Ernst et al. 2006; Table 3 and Appendix). Although the Taï National Park is a lowland habitat, it shares 62% of the amphibian species with our study area, emphasising the high diversity of the Upper Guinea rainforests. In addition to this richness of lowland rainforest, the Nimba Mountains are thought to be a refuge area where different faunas met and survived. For instance, *Arthroleptis krokosua* is otherwise only known from Ghana and Guinea, and in contrast *Odontobatrachus arndti* and *O. natator* may be in contact with each other

on the southwestern slopes of the mountain. Some species are endemic to the area (*N. occidentalis*, *H. nimbae*), or seem to have their range center there: *A. cruscolum*, *Kassina cochranæ*, *Ptychadena retropunctata*, *P. submascareniensis*, *P. arnei*, and *P. pujoli*. The Nimba Mountains are supposed to have represented a forest refugium during dry Pleistocene times (Maley 1996), thus forest species may have survived unfavorable conditions for prolonged times in this area. Only with strict protection of the Nimba Mountains and its habitats, will such survival be possible in the future as well.

## Conclusion

Our discoveries of *Arthroleptis cruscolum* and *Ptychadena retropunctata* added two species to the list of the amphibian fauna of Ivory Coast. The unique and diverse mosaic of habitats on Mounts Nimba supports numerous species and their ecosystem services. Our results should be taken as a baseline for future management, monitoring, and conservation activities. Most urgently, management efforts should try to mitigate bush-fires in mountain grasslands, e.g., to protect the viviparous Nimba toad, *N. occidentalis*. Furthermore, we recommend the strict protection of the remaining forest habitats. At lower elevations, it is important to encourage local activities concerning reforestation of previously forested areas and the conservation of (sacred) village forests from which some rare or endemic (e.g., *H. nimbae*, *K. cochranæ*, *P. arnei*, *P. pujoli*), as well as threatened species (e.g., *Leptopelis macrotis*) benefit.

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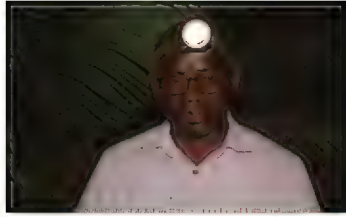


**Kouassi Philippe Kanga** is a Ph.D. candidate at the Université Jean Lorougnon Guédé in Daloa, Ivory Coast. His research topic focuses on amphibian diversity and its spatio-temporal dynamics in the Ivorian part of Mount Nimba. Specifically, he aims to link amphibian assemblages with species functions in this ecosystem, and to assess how species react in response to environmental changes.



**N'Goran Germain Kouamé** is an Ivorian herpetologist and biologist. He is senior lecturer and head of the section biodiversity at the Université Jean Lorougnon Guédé, Daloa, Ivory Coast, and the current Chair of the West African region of the IUCN SSC Amphibian Specialist Group (ASG). He holds a Diploma and a Ph.D. in natural sciences from the Université d'Abobo-Adjamé (actually Université Nangui Abrogoua), Abidjan, Ivory Coast, where he used leaf-litter frogs (*Phrynobatrachus* spp.) as models to determine the conservation status of the Banco National Park, one of the rare remaining primary forests situated in the midst of a West African mega-city. His current research interests mainly focus on the taxonomy, ecology, distribution, and conservation of rare, threatened, and new amphibian species in Ivory Coast.

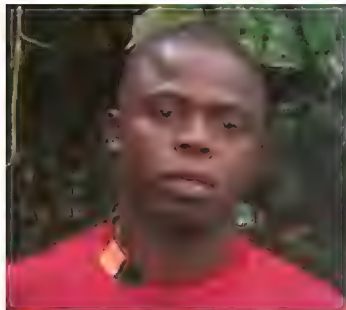
## Amphibians of the Nimba Mountains (Ivorian part)



**Parfait Zogbassé** is a postgraduate of the Université Jean Lorougnon Guédé (Daloa, Ivory Coast) with an M.Sc. in Herpetology. His current research focuses on the taxonomy, systematics, and population ecology of grassfrogs (*Ptychadena* spp.) in western Ivory Coast. Parfait also teaches natural sciences in a secondary school in Daloa as a public servant for the Ivorian government.



**Basseu Aude-Inès Gongomin** is a Ph.D. candidate at the Université Jean Lorougnon Guédé (Daloa, Ivory Coast). Her current research topic focuses on the taxonomy, DNA barcoding, and population ecology of endemic amphibians of the Ivorian part of the Nimba Mountains.



**Konan Laurent Agoh** is a postgraduate student at the Université Jean Lorougnon Guédé (Daloa, Ivory Coast) with an M.Sc. in Herpetology. His research interest focuses on the diversity and ecology of amphibian assemblages in forest fragments of the valley of Bandama River, an area which lies between Lamto Faunal Reserve (central Ivory Coast) and Banco rainforest (southern Ivory Coast).



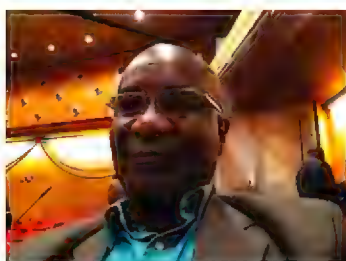
**Akoua Michèle Kouamé** is a recent graduate of the Université Nangui Abrogoua (Abidjan, Ivory Coast) with a Ph.D. in Herpetology. Her research focused on the life-history of reedfrogs in Azagny National Park, a Ramsar site situated in southern-central Ivory Coast. Her research was supervised by Professor Abouo Béatrice Adepo-Gourène and Dr. N’Goran Germain Kouamé.



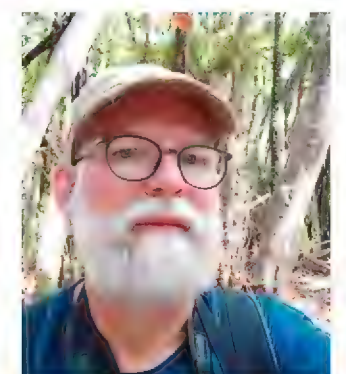
**Jean Christophe Béhibro YN Konan** is a recent graduate of the Université Nangui Abrogoua (Abidjan, Ivory Coast) with a Ph.D. in Herpetology. His research interests focus on the diversity, taxonomy, systematics, ecology, and conservation of amphibians in Azagny National Park, a Ramsar site situated in southern-central Ivory Coast. His research was supervised by Professor Abouo Béatrice Adepo-Gourène and Dr. N’Goran Germain Kouamé.



**Abouo Béatrice Adepo-Gourène** is a professor at the Université Nangui Abrogoua (Abidjan, Ivory Coast). Her research focuses on using animal genetics to better predict gene expression. She is interested in the taxonomy and systematics of freshwater crustaceans, and the conservation of Ivorian amphibians.



**Germain Gourène** is the professor and founder of the “Laboratoire d’Environnement et de Biologie Aquatique” at the Université d’Abobo-Adjamé (actually Université Nangui Abrogoua, Abidjan, Ivory Coast). His research focuses on the systematics and taxonomy of fishes, with an emphasis on Africa; other areas covered include ecology and aquaculture. In addition to his research interest on fishes, Germain is interested in the conservation of aquatic invertebrates and amphibians in the Banco National Park. Germain has served as Vice-President and President of the University of Abobo-Adjamé for 10 years, and was elected as deputy of the locality of Kounahiri (Central Ivory Coast) from 2012–2016.



**Mark-Oliver Rödel** is the head of the department of “Diversity Dynamics” at the Museum für Naturkunde, Berlin, Germany. He has studied the systematics, taxonomy, biogeography, and ecology of African amphibians for almost 30 years. With his group, comprising students from around the world, he currently runs projects in Germany, Guinea, Ivory Coast, Cameroon, Mozambique, and Malaysian Borneo. His special interest is on how species and ecological communities react to environmental changes. He has authored or co-authored more than 350 scientific publications, including several books.

**Appendix.** Checklist of the amphibian species recorded in some mountain, highland, and lowland areas of the western part of the Upper Guinean zones. Abbreviations: LF = Lowland Forest; LMEF = Lowland to Mid-Elevation Forest; DCF = Diéké Classified Forest (Rödel et al. 2004); FD = Fouta Djallon Highlands (Hillers et al. 2008a; Barej et al. 2015); MB = Mount Béro (Rödel et al. 2004); MN (Guinea) = Mount Nimba in Guinea (Guibé and Lamotte 1958a, 1963; Laurent 1958; Schiøtz 1967; Lamotte and Ohler 1997, 2000; Rödel et al. 2004; Barej et al. 2015; Sandberger-Loua et al. 2018; Schäfer et al. 2019); MP = Mount Péko National Park (Rödel and Ernst 2003); MS = Mount Sangbé National Park (Rödel 2003; Barej et al. 2015); SR = Simandou range (Parker 1936; Taylor 1968; Rödel and Bangoura 2004); TNP = Taï National Park (Rödel and Ernst 2004; Ernst et al. 2006); ZCF = Ziamia Classified Forest (Böhme 1994a,b; Chabanaud 1920, 1921). Literature records follow recent taxonomic changes.

Taxa	Western Ivory Coast				Guinea					
	Mountain and highland areas			LF	Mountain and highland areas					LMEF
	MN (this study)	MP	MS	TNP	FD	MB	MN	SR	ZCF	DCF
<b>Dermophiidae</b>										
<i>Geotrypetes pseudoangeli</i>								X		
<i>Geotrypetes seraphini</i>				X			X	X	X	
<b>Arthroleptidae</b>										
<i>Arthroleptis cruscolum</i>	X						X			
<i>Arthroleptis krokosua</i>							X			
<i>Arthroleptis poecilonotus-complex*</i>	X	X	X	X	X	X	X	X	X	X
<i>Astylosternus occidentalis</i>	X	X	X	X	X		X	X	X	
<i>Cardioglossa occidentalis</i>	X			X		X	X	X		X
<i>Leptopelis bufonides</i>					X					
<i>Leptopelis macrotis</i>	X			X			X	X		X
<i>Leptopelis occidentalis</i>	X		X	X						
<i>Leptopelis spiritusnoctis</i>	X	X	X	X	X	X	X	X		X
<i>Leptopelis viridis</i>	X	X	X		X		X	X	X	
<b>Bufonidae</b>										
<i>Nimbaphrynoides occidentalis</i>	X						X			
<i>Sclerophrys chevalieri</i>				X		X	X	X	X	X
<i>Sclerophrys maculata</i>	X	X	X	X	X	X	X	X	X	X
<i>Sclerophrys regularis</i>	X		X	X	X		X	X	X	X
<i>Sclerophrys taiensis</i>				X						
<i>Sclerophrys togoensis</i>	X			X		X	X	X		X
<b>Conrauidae</b>										
<i>Conraua alleni</i>	X		X			X	X	X		X
<i>Conraua</i> sp. 'fouta'					X					
<b>Dicroglossidae</b>										
<i>Hoplobatrachus occipitalis</i>	X	X	X	X	X		X	X	X	X
<b>Hemisotidae</b>										
<i>Hemistus guineensis</i>		X		X						
<i>Hemistus marmoratus</i>	X		X				X	X		
<b>Hyperoliidae</b>										
<i>Acanthixalus sonjae</i>				X						
<i>Afixalus dorsalis</i>	X		X	X		X	X	X	X	X
<i>Afixalus fulvovittatus</i>	X					X	X	X	X	X
<i>Afixalus nigeriensis</i>				X						
<i>Afixalus vibekensis</i>				X						
<i>Afixalus vittiger</i>			X					X		
<i>Afixalus weidholzi</i>			X				X		X	

## Amphibians of the Nimba Mountains (Ivorian part)

**Appendix (continued).** Checklist of the amphibian species recorded in some mountain, highland, and lowland areas of the western part of the Upper Guinean zones. Abbreviations: LF = Lowland Forest; LMEF = Lowland to Mid-Elevation Forest; DCF = Diéké Classified Forest (Rödel et al. 2004); FD = Fouta Djallon Highlands (Hillers et al. 2008a; Barej et al. 2015); MB = Mount Béro (Rödel et al. 2004); MN (Guinea) = Mount Nimba in Guinea (Guibé and Lamotte 1958a, 1963; Laurent 1958; Schiøtz 1967; Lamotte and Ohler 1997, 2000; Rödel et al. 2004; Barej et al. 2015; Sandberger-Loua et al. 2018; Schäfer et al. 2019); MP = Mount Péko National Park (Rödel and Ernst 2003); MS = Mount Sangbé National Park (Rödel 2003; Barej et al. 2015); SR = Simandou range (Parker 1936; Taylor 1968; Rödel and Bangoura 2004); TNP = Taï National Park (Rödel and Ernst 2004; Ernst et al. 2006); ZCF = Ziama Classified Forest (Böhme 1994a,b; Chabanaud 1920, 1921). Literature records follow recent taxonomic changes.

Taxa	Western Ivory Coast				Guinea					
	Mountain and highland areas			LF	Mountain and highland areas					LMEF
	MN (this study)	MP	MS	TNP	FD	MB	MN	SR	ZCF	DCF
<i>Hyperolius chlorosteus</i>	X	X	X	X		X	X	X		X
<i>Hyperolius concolor</i>	X	X	X	X		X	X	X	X	X
<i>Hyperolius fusciventris fusciventris</i>	X	X		X		X	X	X	X	X
<i>Hyperolius guttulatus</i>	X	X	X	X			X			X
<i>Hyperolius igbettensis</i>			X					X		
<i>Hyperolius lamottei</i>	X	X				X	X	X		
<i>Hyperolius nimbae</i>	X									
<i>Hyperolius nitidulus</i>			X		X	X	X	X	X	
<i>Hyperolius occidentalis</i>					X					
<i>Hyperolius picturatus*</i>	X	X	X	X	X	X	X	X	X	X
<i>Hyperolius soror</i>	X			X			X		X	
<i>Hyperolius cf. sylvaticus</i>	X			X						
<i>Hyperolius zonatus</i>			X	X		X	X		X	X
<i>Hyperolius</i> sp. 'lamtoensis'				X						
<i>Hyperolius</i> sp. 'Ziama'									X	
<i>Hyperolius</i> sp.	X									
<i>Kassina arboricola</i>		X	X							
<i>Kassina cochranæ</i>	X						X	X	X	
<i>Kassina fusca</i>			X		X					
<i>Kassina lamottei</i>				X						
<i>Kassina schioetzi</i>		X	X							
<i>Kassina senegalensis</i>			X		X					
<i>Phlyctimantis boulengeri</i>		X		X						X
<b>Odontobatrachidae</b>										
<i>Odontobatrachus arndti</i>	X		X				X			
<i>Odontobatrachus fouta</i>					X					
<i>Odontobatrachus natator</i>						X		X		
<i>Odontobatrachus smithi</i>					X					
<i>Odontobatrachus ziama</i>								X	X	
<b>Phrynobatrachidae</b>										
<i>Phrynobatrachus alleni</i>	X	X	X	X		X	X	X	X	X
<i>Phrynobatrachus annulatus</i>	X			X			X	X		
<i>Phrynobatrachus calcaratus</i>			X	X	X		X			
<i>Phrynobatrachus francisci</i>	X		X							
<i>Phrynobatrachus fraterculus</i>	X			X			X	X		X
<i>Phrynobatrachus guineensis</i>	X			X			X	X		X
<i>Phrynobatrachus gutturosus*</i>	X	X	X	X			X	X		X

**Appendix (continued).** Checklist of the amphibian species recorded in some mountain, highland, and lowland areas of the western part of the Upper Guinean zones. Abbreviations: LF = Lowland Forest; LMEF = Lowland to Mid-Elevation Forest; DCF = Diéké Classified Forest (Rödel et al. 2004); FD = Fouta Djallon Highlands (Hillers et al. 2008a; Barej et al. 2015); MB = Mount Béro (Rödel et al. 2004); MN (Guinea) = Mount Nimba in Guinea (Guibé and Lamotte 1958a, 1963; Laurent 1958; Schiøtz 1967; Lamotte and Ohler 1997, 2000; Rödel et al. 2004; Barej et al. 2015; Sandberger-Loua et al. 2018; Schäfer et al. 2019); MP = Mount Péko National Park (Rödel and Ernst 2003); MS = Mount Sangbé National Park (Rödel 2003; Barej et al. 2015); SR = Simandou range (Parker 1936; Taylor 1968; Rödel and Bangoura 2004); TNP = Taï National Park (Rödel and Ernst 2004; Ernst et al. 2006); ZCF = Ziamia Classified Forest (Böhme 1994a,b; Chabanaud 1920, 1921). Literature records follow recent taxonomic changes.

Taxa	Western Ivory Coast				Guinea					
	Mountain and highland areas			LF	Mountain and highland areas					LMEF
	MN (this study)	MP	MS	TNP	FD	MB	MN	SR	ZCF	DCF
<i>Phrynobatrachus latifrons</i>	X	X		X	X	X	X	X	X	X
<i>Phrynobatrachus liberiensis</i>	X	X	X	X		X	X	X		X
<i>Phrynobatrachus natalensis</i>	X		X		X	X	X	X		X
<i>Phrynobatrachus phyllophilus</i>	X	X		X			X	X		X
<i>Phrynobatrachus plicatus</i>		X	X	X		X	X	X		X
<i>Phrynobatrachus taiensis</i>				X						
<i>Phrynobatrachus tokba</i>	X		X	X	X	X	X		X	X
<i>Phrynobatrachus villiersi</i>				X						
<i>Phrynomantis microps</i>			X							
<b>Pipidae</b>										
<i>Xenopus tropicalis</i>	X	X	X	X			X	X	X	X
<b>Ptychadenidae</b>										
<i>Ptychadena aff. aequiplicata*</i>		X	X	X			X	X	X	X
<i>Ptychadena arnei</i>	X									
<i>Ptychadena bibroni</i>	X	X	X	X	X		X	X	X	X
<i>Ptychadena longirostris</i>	X	X	X	X	X		X	X	X	X
<i>Ptychadena mascareniensis*</i>			X	X		X	X	X	X	X
<i>Ptychadena oxyrhynchus</i>	X				X		X	X		
<i>Ptychadena pujoli</i>	X						X			
<i>Ptychadena pumilio</i>	X		X	X	X	X		X		X
<i>Ptychadena retropunctata</i>	X					X	X	X		
<i>Ptychadena schillukorum</i>		X								
<i>Ptychadena stenocephala</i>	X		X							
<i>Ptychadena submascareniensis</i>	X					X	X	X		
<i>Ptychadena superciliaris</i>				X			X	X	X	X
<i>Ptychadena tellinii</i>			X		X					
<i>Ptychadena tournieri</i>	X						X	X		
<i>Ptychadena trinodis</i>					X					
<b>Pyxicephalidae</b>										
<i>Aubria subsigillata</i>				X						
<b>Ranidae</b>										
<i>Amnirana fonensis</i>								X		
<i>Amnirana galamensis</i>			X							
<i>Amnirana occidentalis</i>				X			X	X	X	X
<i>Amnirana</i> sp. 'albolabris west'	X	X	X	X		X	X	X	X	X
<b>Rhacophoridae</b>										
<i>Chiromantis rufescens</i>	X	X		X						X
<b>Total number of species</b>	53	29	44	53	26	28	56	52	31	39